EUROPEAN SOUTHERN OBSERVATORY

Organisation Européene pour des Recherches Astronomiques dans l'Hémisphère Austral
Europäische Organisation für astronomische Forschung in der südlichen Hemisphäre

ESO - European Southern Observatory
Karl-Schwarzschild Str. 2, D-85748 Garching bei München

Very Large Telescope

Paranal Science Operations

VIMOS User Manual

Doc. No. VLT-MAN-ESO-14610-3509

Issue 94.0, Date 24/05/2014

Prepared/Edited by VIMOS IOT/S. Mieske/F. Selman .....
Date Signature

Approved A. Smette .....
Date Signature

Released C. Dumas .....
Date Signature

This page was intentionally left blank

The list of people that have contributed to the preparation of this document, at different times, includes:

Stefano Bagnulo
Stephane Brillant
Paul Bristow
Peter Hammersley
Gianni Marconi
Steffen Mieske
Marina Rejkuba
Ruben Sanchez-Janssen
Fernando J. Selman
VIRMOS Consortium
Burkhard Wolff

This page was intentionally left blank

Table 1: Change Record

Issue/Rev.	Date	Section/Parag. affected	Reason/Initiation/Documents/Remarks
94.0	May 24, 2014	3.4.1, 3.5.7, 6.3.2, 7.2.1, 7.2.4	Minor changes after MHI feedback.
92.2	May 28, 2013	2.4.1, 2.8.5, 3.5.3, 3.6.1	Minor changes after MHI feedback.
92.1	May 23, 2013	Sec. 1.4.1, 2.1, 2.2.2 (Fig. 2.3), 2.4, 2.4.1 (Fig. 2.6), 2.8.5, 3.4.1, 3.5.3, 3.6.1, 6.2.1, 6.2.3, 6.2.8, 7.3.1	Version for P92 Phase II.
92.0	Feb 25, 2013	Tables 2.6, 2.7, 2.9, and 2.10	Version for P92 Phase I. Corrected wavelength coverage of new HR_blue grism.
91.1	Nov 24, 2012	6.2.6	Modified recomendations for reference objects. (MRE 2012-09-14 email). Version for P91 Phase II
91.0	Sep 3, 2012		Version for P91, Phase I.
90.1	May 29, 2012		Added PILMOS chapter. Released for P90 Phase II.
90.0	Feb 24, 2012		released for P90 Phase I.
89.0	Dec 28, 2011	2.3, 2.4, and 2.8	released for P89 Phase II. Added new HR_blue grism info. Added subsections in 2.8
88.0	Sept 15, 2010	several	Released for P88 Phase I and II.
87.1	Dec 12, 2010	several	Released for P87 Phase II. Section 2.2.4 with characteristics of band passes with new detectors. Several places: AFC update. Instrument shortcomings section added.
87.0	Aug 28, 2010	all	Modified for new detectors and AFC system. To be used in Phase I P87.
86.1	Mar 03, 2010	Ch. 2, 3	Incorporated some of the feedback from IOT. Added QE graph of new CCDs.
86.0	Feb 27, 2010	Ch. 2, 3	Phase I P86. Info about new CCDs and upgrade project. New policy for waivers for OB duration in SM.
85.2	Nov 30, 2009	Chapter 4	Further descriptions of the SkyFlat templates. Release for P85 Phase II.
85.1	Nov 29, 2009	Chapter 4	Added automatic IP tables to P85 template description. Added img_SkyFlat templates and description. Added further explanation to Chapter 4 Introduction. Release for P85 Phase II.
85.0	Sep 1, 2009	1.5, 3.4.3, 4.7.7	Added VIMOS_IFU_TwFlat template description. Normal update for P85 Phase I.
84.4	July 1, 2009	3.4.3, 4.6.x	Further offsets description and other minor fixes for Phase II.
84.3	March 26, 2009	4.5.1, 4.6.1	Minor fixes
84.2	March 26, 2009	4.5.1, 4.6.1	Fixed wrong description of offsets and created new Figs 4.4 and 4.5

continued on next page

Table 1: *continued*

Issue/Rev.	Date	Section/Parag. affected	Reason/Initiation/Documents/Remarks
84.1	March 11, 2009	4.5.1, 4.6.1, 4.6.2, 4.6.3	Clarified offsets description. Modified reference object position recommendation..
83.0	Aug 31, 2008		Pre-imaging validity comment and release for P83 Phase I
82.1	Mar 05, 2008		release for P82 Phase I and II
81.0	Aug 31, 2007		release for P81 (Phase I and II)
79.1	Dec 13, 2006	Added clarifications about instrument FoV (Phase II)	release for P79 (Phase II)
79.0	Aug 23, 2006	front page and fonts	release for P79 (Phase I)
78.1	Jun 06, 2006	all	release for P78 (Phase II)
78.0	Mar 01, 2006	none	release for P78 (Phase I)
77.2	Dec 01, 2005	Appendix	release for P77 (Phase II)
77.0	Aug 31, 2005	3.6.1, 3.7.2	release for P77 (Phase I)
76.1	June 30, 2005	2.1;2.2;2.3;2.6;3.4; 3.5;3.6;3.7;4.6	release for P76 (Phase II)
76.0	Mar 21, 2005	2.7; 3.5.7; 3.6.6; 3.7.7	release for P76 (Phase I)
5.0	Nov 26, 2004	all	release for P75 (phase II) and P76 (Phase I)
1.3	Jun 14, 2004	all	release for P74 (phase II) and P75 (Phase I)
1.2	Jan 12, 2004	all	release for P73 (phase II) and P74 (Phase I)
1.1	July 14 2003	all	release for P72 (phase II) and P73 (Phase I)
1.0	Feb 11, 2003	all	first release for P71 (phase II) and P72 (Phase I)
draft	Oct 24, 2002	all	Draft delivered by VIRMOS Consortium

Contents

1 Introduction **1**

1.1 Scope . . . 1
1.2 More Information on VIMOS . . . 1
1.3 Contact Information . . . 1
1.4 Version notes, change track . . . 2
1.4.1 Version 94.0 . . . 2
1.4.2 Version 92.1 . . . 2
1.4.3 Version 92.0 . . . 2
1.4.4 Version 90.1 . . . 3
1.4.5 Version 89.0 . . . 3
1.4.6 Version 88.0 . . . 3
1.4.7 Version 87.0 . . . 3
1.4.8 Version 86.0 . . . 3
1.4.9 Version 85.0 . . . 4
1.4.10 Version 84.0 . . . 4
1.4.11 Version 80.0 . . . 4
1.4.12 Version 79.1 . . . 4
1.4.13 Version 79.0 . . . 4
1.4.14 Version 78.1 . . . 4
1.5 Acknowledgments . . . 4

2 Instrument Characteristics **5**

2.1 Overview . . . 5
2.1.1 Instrument modes . . . 7
2.2 Imaging . . . 7
2.2.1 IMG mode: orientation of the field of view . . . 8
2.2.2 Image Quality . . . 8
2.2.3 Imaging Filters . . . 8
2.2.4 Zero points . . . 8
2.3 Multi-Object Spectroscopy (MOS) . . . 12
2.3.1 Spectral range . . . 12
2.3.2 Spectral resolution . . . 12
2.3.3 Multiplex characteristics . . . 12
2.3.4 MOS mode: orientation of the field of view . . . 13
2.4 Integral Field Unit (IFU) . . . 13

2.4.1 IFU mode: orientation of the field of view . . . 14
2.4.2 Fiber arrangement and spatial characteristics . . . 14
2.4.3 Spectral range . . . 17
2.4.4 Spectral resolution . . . 17
2.4.5 Multiplex characteristics . . . 17
2.5 Detectors . . . 19
2.5.1 Detector system . . . 19
2.5.2 More information . . . 21
2.6 Calibration Units . . . 21
2.7 AFC: Active Flexure Compensation . . . 22
2.8 Known shortcomings of the instrument . . . 22
2.8.1 IFU masks vignetting in IMG and MOS mode . . . 22
2.8.2 IFU fringing . . . 22
2.8.3 **[SOLVED]** Non-optimal focus for some grisms . . . 22
2.8.4 **[SOLVED]** Defocusing at some adapter angles . . . 23
2.8.5 **[SOLVED]** IFU focusing issues . . . 23
2.8.6 Spectrum rotation . . . 23
2.8.7 Temperature dependent bias level . . . 24
2.8.8 Temperature dependent image scale . . . 24

3 Observing with VIMOS **25**
3.1 Interactions with the telescope . . . 25
3.1.1 Guide stars and Guidecam software tool . . . 25
3.1.2 Cumulative offsets . . . 26
3.1.3 Telescope and Instrument Focus . . . 26
3.2 Atmospheric Dispersion . . . 26
3.3 Fringing and Flexures . . . 26
3.4 Imaging (IMG) . . . 27
3.4.1 Pre-imaging . . . 28
3.4.2 Science imaging . . . 28
3.4.3 IMG mode: calibration plan . . . 29
3.4.4 IMG mode: pipeline . . . 29
3.4.5 IMG mode: Exposure Time Calculator . . . 29
3.5 Multi-Object Spectroscopy (MOS) . . . 29
3.5.1 Pre-imaging . . . 29
3.5.2 PILMOS: Pre-imageless MOS observations . . . 30
3.5.3 Rotator on sky . . . 30
3.5.4 VIMOS Mask Preparation Software (VMMPS) . . . 30
3.5.5 Finding charts . . . 31
3.5.6 Visitors using MOS . . . 32
3.5.7 MOS mode: grism+filter setup . . . 32
3.5.8 MOS mode: attached night time calibrations . . . 32
3.5.9 MOS mode: calibration plan . . . 32
3.5.10 MOS mode: pipeline . . . 32

3.5.11 MOS mode: Exposure Time Calculator . . . 33
3.6 Integral Field Unit (IFU) . . . 33
3.6.1 Acquisition accuracy . . . 33
3.6.2 Dithering/jitter pattern . . . 33
3.6.3 IFU mode: grism + filter setup . . . 33
3.6.4 IFU mode: attached night time calibrations . . . 34
3.6.5 IFU mode: calibration plan . . . 34
3.6.6 IFU mode: pipeline . . . 34
3.6.7 IFU mode: Exposure Time Calculator . . . 34
3.7 VIMOS overheads and OB duration . . . 35

4 User Guide to the VIMOS Templates **37**
4.1 Introduction . . . 37
4.2 Template names . . . 37
4.3 Things to know - Reminder . . . 37
4.4 List of templates . . . 38
4.5 Acquisition templates . . . 40
4.5.1 VIMOS_img_acq_Preset . . . 40
4.5.2 VIMOS_img_acq_FlatSky . . . 42
4.5.3 VIMOS_mos_acq_Mask . . . 43
4.5.4 VIMOS_mos_acq_Standard . . . 46
4.5.5 VIMOS_ifu_acq_Preset . . . 48
4.6 Science templates . . . 50
4.6.1 VIMOS_img_obs_Offset . . . 50
4.6.2 VIMOS_mos_obs_Offset . . . 53
4.6.3 VIMOS_ifu_obs_Offset . . . 55
4.7 Calibration Templates . . . 57
4.7.1 VIMOS_img_cal_FlatSky . . . 57
4.7.2 VIMOS_img_cal_Photom . . . 58
4.7.3 VIMOS_img_cal_Astrom . . . 59
4.7.4 VIMOS_mos_cal_NightCalib . . . 60
4.7.5 VIMOS_mos_cal_Standard . . . 61
4.7.6 VIMOS_ifu_cal_Specphot . . . 62
4.7.7 VIMOS_ifu_cal_NightCalib . . . 64
4.7.8 VIMOS_ifu_cal_TwFlat . . . 65

5 Guidecam Tutorial **67**
5.1 Getting started with Guidecam . . . 67
5.2 The main ‘Guidecam’ GUI . . . 67
5.3 The ‘USNO at ESO’ panel . . . 68
5.4 Selecting the Guide Star . . . 69
5.5 Generating Finding Charts . . . 70
5.6 Guide Stars: Policy . . . 70

6 VMMPS Tutorial **73**

6.1 The VMMPS philosophy . . . 73
6.1.1 What does VMMPS do? . . . 73
6.1.2 This is *not* FIMS - you have little chance for interaction . . . 73
6.1.3 The importance of your catalog . . . 74
6.1.4 The different catalogs that you can come with . . . 74
6.2 Step-by-step guide . . . 75
6.2.1 Step 0 (most crucial): Getting ready – preparing your catalogs . . . 75
6.2.2 Step 1: What is your starting point? . . . 80
6.2.3 Step 2: Transforming your `contributed` catalog into a `VIMOS catalog` . . . 82
6.2.4 Step 3: Starting VMMPS for mask definition . . . 85
6.2.5 Step 4 (optional): Re-arranging your `VIMOS catalog` . . . 87
6.2.6 Step 5: First pass – defining special objects . . . 89
6.2.7 Step 6: The automatic slit assignment – your first ADP draft . . . 96
6.2.8 Step 7 (optional): Fine tuning / last corrections . . . 99
6.2.9 Step 8: Writing your final ADP – you have succeeded . . . 102
6.2.10 Loading/verifying previously defined mask . . . 103
6.3 Troubleshooting and known problems. . . . 104
6.3.1 Cross-correlation task . . . 104
6.3.2 Automatic slit assignment . . . 104
6.3.3 Problems with checksum in ADP files . . . 105
6.3.4 ADP files and FITS headers . . . 105
6.3.5 Other problems . . . 106
6.4 Examples of catalogs . . . 107
6.4.1 A contributed catalog . . . 107
6.4.2 A VIMOS pre-image catalog . . . 108
6.4.3 A VIMOS catalog . . . 109
6.4.4 Example of an ADP file . . . 110
6.5 User check list . . . 114

7 PILMOS Tutorial **115**
7.1 Introduction . . . 115
7.2 Requirements and Restrictions for PILMOS usage . . . 115
7.2.1 Restrictions . . . 115
7.2.2 Catalogue requirements . . . 115
7.2.3 Other Considerations . . . 116
7.2.4 PILMOS features to be aware of . . . 116
7.3 Preparation of MOS Masks without a Pre-Image . . . 117
7.3.1 Step 1: PILMOS (Guidecam) Application . . . 117
7.3.2 Step 2: VMMPS . . . 119

Appendices **123**

A VIMOS Filters **123**

B VIMOS Grisms **129**

C Old detector system: until May 2010 **135**
C.1 Detector read-out modes . . . 135
C.2 Controllers . . . 136
C.3 Read-out noise and conversion factor . . . 136
C.4 Fringing . . . 136

D Abbreviations and Acronyms **137**

Index **139**

List of Figures

2.1 VIMOS Optical layout . . . 5
2.2 VIMOS Opto-Mechanical layout . . . 7
2.3 VIMOS FoV orientation: relative positioning on sky . . . 9
2.4 VIMOS FoV orientation . . . 10
2.5 VIMOS IFU FoV orientation . . . 15
2.6 VIMOS IFU FoV orientation 2 . . . 15
2.7 IFU details of the fiber modules . . . 16
2.8 IFU fiber numbering scheme . . . 16
2.9 Quantum efficiency vs λ for new detectors . . . 19
2.10 IFU Vignetting . . . 23

3.1 Atmospheric Dispersion: Example . . . 27
3.2 VMMPS Graphical User Interface . . . 31

4.1 P2PP: example of a pre-imaging OB . . . 41
4.2 P2PP: Example of a MOS OB . . . 44
4.3 P2PP: VIMOS ADP browser window. . . . 45
4.4 VIMOS_img_obs_Offset: Offsets in DETECTOR mode . . . 52
4.5 VIMOS_img_obs_Offset: Offsets in SKY mode . . . 52

5.1 Guidecam main panel . . . 68
5.2 Guidecam: Guide Probe Settings panel . . . 69
5.3 Guidecam: USNO at ESO panel . . . 70

7.1 Guide probe setting panel: Contributed catalogue button . . . 117

A.1 filter transmission curves . . . 124
A.2 filter transmission curves . . . 125
A.3 Order Sorting Filter transmission curves . . . 126
A.4 Order Sorting Filter transmission curves . . . 127

B.1 Efficiency curve of the low resolution grisms. . . . 130
B.2 Efficiency curve of the medium resolution grism. . . . 131
B.3 Efficiency curve of the high resolution grisms. . . . 132
B.4 Efficiency curve of the high resolution grisms. . . . 133
B.5 Efficiency curve of the high resolution grisms. . . . 133

List of Tables

1 Change record v

2.1 VIMOS opto-mechanical characteristics 6
2.2 VIMOS Imaging characteristics and performance 8
2.3 Measured imaging zero points 11
2.4 Calculated isophotal fluxes and wavelengths 11
2.5 Standard grism / filter combinations 12
2.6 MOS: spectral resolution and spectral ranges observed using the mask for spectrophotometric standard stars 13
2.7 Spectral coverage $\Delta\lambda$ for three positions of the slit in field of view (MOS mode) 14
2.8 IFU Modes 17
2.9 Spectral characteristics in IFU mode 18
2.10 IFU: spectral coverage in the various quadrants 18
2.11 Basic characteristics of the new VIMOS CCDs 20
2.12 New Detector Readout Modes 20
2.13 New detector read-out noise and conversion factors 20

3.1 VIMOS Calibration Plan: IMG Mode 29
3.2 VIMOS Calibration Plan: MOS Mode 33
3.3 VIMOS Calibration Plan: IFU Mode 34

A.1 Characteristics of the VIMOS filters 123

C.1 Basic characteristics of the (old) VIMOS CCDs 135
C.2 Detector Readout Modes 135
C.3 Old detectors read-out noise and conversion factors 136

Chapter 1

Introduction

1.1 Scope

The VIMOS User's Manual is intended to provide information on the following topics:

- Overall description of the instrument (Sect. 2)
- Observing with VIMOS (Sect. 3)
- Observing and calibration templates (Sect. 4)

1.2 More Information on VIMOS

All VIMOS Manuals are available on the VIMOS instrument WEB pages together with the most updated informations on the instrument:

`http://www.eso.org/sci/facilities/paranal/instruments/vimos/`

Information and software tools for the preparation of service and visitor mode observations with VIMOS are available at:

`http://www.eso.org/sci/observing/phase2`
`http://www.eso.org/sci/observing/phase2/SMGuidelines.html`

In particular, information concerning mask preparation with VMMPS and guide star selection with Guidecam is given in the following additional pages:

http://www.eso.org/sci/observing/phase2/SMGuidelines/VMMPS.VIMOS.html
http://www.eso.org/sci/observing/phase2/SMGuidelines/GuidecamVIMOS.VIMOS.html

Visiting astronomers will find further instructions on the Paranal Science Operations WEB page and the Paranal Observatory home page:

`http://www.eso.org/sci/facilities/paranal/`
`http://www.eso.org/sci/facilities/paranal/sciops/`

1.3 Contact Information

In case of specific questions related to Service Mode observations and proposal preparation please contact the ESO User Support Department:

usd-help@eso.org

For visitor mode observations please contact the Paranal Science Operations Team:

paranal@eso.org

1.4 Version notes, change track

The first edition of this User Manual was delivered by the VIRMOS Consortium (P.I.: O. Le Fèvre).

1.4.1 Version 94.0

For Phase II, P94

- Pre-imaging users are requested to indicate whether they need a photometric standard in the same night
- MOS users are reminded to use similar wavelength in aquisition and science
- Clarification of a core dump bug message in VMMPS
- Added list of PILMOS features to be aware of

1.4.2 Version 92.1

For Phase II, P92.

- Added recommendation to use slit-width below $4''$ to avoid saturating screen flats.
- Added recommendation to use fewer than 500 stars for cross-correlation in VMMPS.
- Now PILMOS observations can be used for the same orientations on sky as the observations prepared with pre-imaging.
- Added date of validity of pre-imaging:
  - **As a consequence of the CCD upgrade, all pre-images taken before the intervention are not valid anymore for MOS follow up observations after the CCD upgrade (i.e. after 31 August 2010).**
  - **The use of pre-imaging taken between 31 August 2010 and 24 May 2011 can result in a systematic overall offset affecting all quadrants the same way, but making field acquisition difficult, specially in crowded fields.**
- Added information about new keywords giving coordinates of actual IFU FoV center.
- Added warnings about IFU pointing in declinations close to the south celestial pole.

1.4.3 Version 92.0

For Phase I, P92. Updated the wavelength coverage of the new HR_blue grism can be found in tables 2.6, 2.7, 2.9, and 2.10.

1.4.4 Version 90.1

This is the version of the VIMOS manual for P90, phase I and phase II. The new HR blue grisms were installed. The peak overall efficiency has been measured to be approximately 25%, compared with 15% previously. See MOS curves at:
http://www.eso.org/sci/facilities/paranal/instruments/vimos/img/VIMOS_newHR_blueHolog_moseff.png.

During P89 we have tested the new Pre-Imageless MOS (PILMOS) mode. This new mode will offer to take multi-object spectroscopic observations with 4 VIMOS masks without the previously mandatory pre-imaging. The fake pre-images will be simulated based on the users contributed catalogue to be used in input for mask creation with VMMPS. We expect to make this mode available fully from P91. If requested via waiver it will also be available for P90 Phase 2 preparation.

Starting during Period 90 we have relaxed the constraint that forces MOS slits to be oriented N-S as follow: for targets at declinations in the range $-45^\circ < \delta < -5^\circ$ we permit observations with slits oriented E-W, with rotator angle set at 0°, and with HA within $\pm$ 3 hrs from meridian. Note that this is still not allowed with PILMOS. Users planning to request slits oriented in this way need to request a pre-imaging run. For a full report see Sanchez-Janssen et al. (2012) in the mos section of the VIMOS web pages..

1.4.5 Version 89.0

This is the version of the VIMOS manual for P89 and later. We expect two major changes in VIMOS affecting users in P89. The first one is the commissioning of new volume-phase holographic HR_blue grisms with increased efficiency compared to the current ones (albeit somewhat reduced resolution). The second is a redesign of the focusing mechanism in all quadrants that we hope will be able to keep correct focus at all rotator angles. The new focusing mechanism will come with new focusing logic that will allow to adjust focus depending on the grism used. These changes will conclude the VIMOS upgrade project.

1.4.6 Version 88.0

This is the version of the document for P88 and later. VIMOS has been running stably after the intervention. Only remaining work to be done are improvements to the focusing units, to ensure proper image quality (and spectral resolution) at any rotator angle, and the installation of the new VPH high resolution blue grism.

1.4.7 Version 87.0

The first part of the VIMOS upgrade project is almost finalized. The instrument has been furnished with the new set of red sensitive detectors, new bi-stable shutters, and an active flexure compensation system. As usually happens in a project like this we could expect things to initially evolve before the finally stabilize, so please visit the VIMOS web pages for the latest news.

1.4.8 Version 86.0

As of this writing (Feb 2010) the new detectors have been characterized, and the upgrade is planned to take place between the months of June and July 2010. If everything goes according to schedule we will have the new detectors and new shutters in normal use during P86. The upgrade project includes the implementation **UP** of an active flexure compensation mechanism which nevertheless will need to be tested before we can commit to a final date for its installation and commissioning.

The Service Mode policy for granting a waiver for OB duration longer than 1h has been clarified. See Sec. 3.7.

1.4.9 Version 85.0

This manual is for P85 preparation. As of this writing (1 Sep 2009) there is an ongoing project that aims to upgrade the instrument. It is foreseen that the detectors will be changed by new deep depletion e2v detectors which will increase the red response and reduce fringing. The changes to the instrument will imply that once VIMOS is upgraded current MOS OBs might need to be redone with new pre-image. Also, the ETC for the current detectors will give discrepant results, specially redward of 700nm. Please look for information in the instrument web pages. We apologize for the problems that this project will generate to the users during P85.

1.4.10 Version 84.0

VMMPS and Guidecam documents were merged into this manual. All the links have been updated to reflect the 2008 changes in the ESO web.

1.4.11 Version 80.0

Some changes in the night time calibration plan

1.4.12 Version 79.1

Substantial chances to the description of the instrument field of view. Changes by S. Bagnulo and M. Rejkuba. Dr. S.L. Morris is acknowledged for having improved Fig. 2.7. An error in Table 5 has been corrected.

1.4.13 Version 79.0

VIMOS manual has been ported to the standard format for VLT manuals. Changes by S. Bagnulo

1.4.14 Version 78.1

Version 78.1 contains more detailed and accurate information about the spectral range that can be observed in spectroscopic modes (MOS and IFU) with the various grisms. Table C.3 has been updated. Hyperlinks have been added to the text. The various sections of the manual have been re-arranged. All changes by S. Bagnulo and M. Rejkuba, comments received by G. Marconi and L. Christensen.

1.5 Acknowledgments

The following institutes have participated to the development of VIMOS:

- Laboratoire d'Astrophysique de Marseille, Marseille, France
- Observatoire de Haute-Provence, Saint-Michel l'Observatoire, France
- Laboratoire d'Astrophysique de l'Observatoire Midi-Pyrénées, Toulouse, France
- Osservatorio Astronomico di Capodimonte, Napoli, Italy
- Istituto di Fisica Cosmica e Tecnologie Relative, Milano, Italy
- Osservatorio Astronomico di Brera, Milano, Italy
- Istituto di Radioastronomia, Bologna, Italy
- Osservatorio Astronomico di Bologna, Bologna, Italy

Chapter 2

Instrument Characteristics

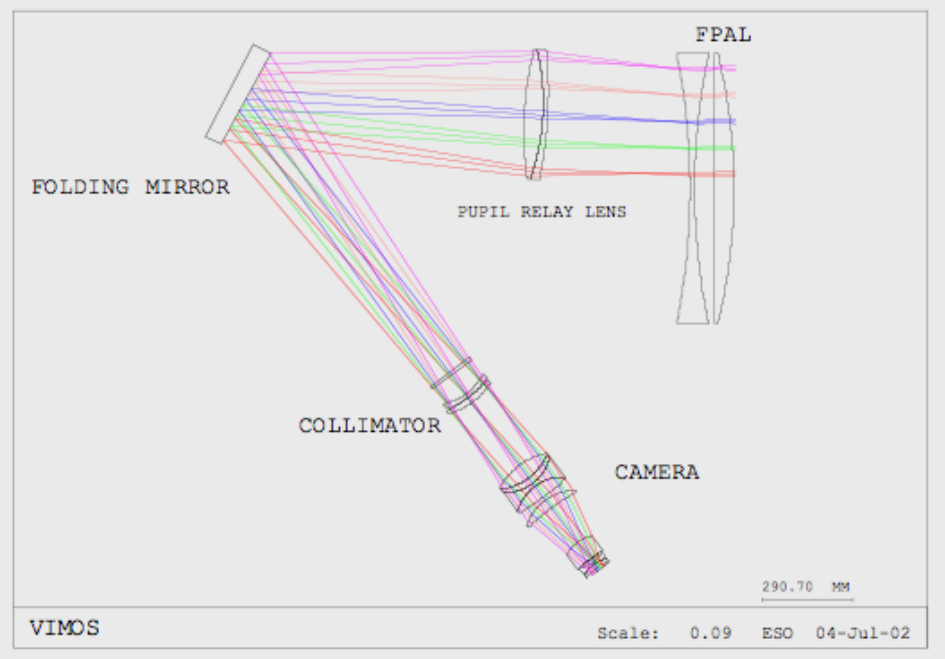


Figure 2.1: VIMOS Optical layout

2.1 Overview

VIMOS is the **Vi**sible **M**ulti-**O**bject **S**pectrograph for the **V**ery **L**arge **T**elescope (VLT) of the **E**uropean **S**outhern **O**bservatory (ESO). This instrument has been built to provide the ESO community with a wide field spectrograph with high throughput and multiplex, dedicated to deep surveys.

VIMOS operates in the 0.37–1.0 μm domain in three main observing modes: direct imaging (IMG), multi-slit spectroscopy (MOS), and integral field spectroscopy (IFU). Because of the large field of view, VIMOS optical path is split into four channels. The four quadrants of the instrument are operated in parallel (i.e., it is not possible to mix modes or filters or grisms between quadrants).

The field of view of the four channels is $4 \times 7' \times 8'$ in IMG and MOS and up to $54'' \times 54''$ in IFU mode in low resolution spectroscopy. It provides an image scale of 0.205"/pixel in MOS and IMG and 0.67" or 0.33" per resolution element in IFU mode depending on the elongator setting used.

Until June 2010 each of the four channels was equipped with a 2048 $\times$ 4096 pixels EEV 44-82, backside illuminated, single layer coating, CCD. Henceforth these will be the old CCD. **Since August 1st, 2010, each**

Table 2.1: VIMOS opto-mechanical characteristics

Instrument Location	Nasmyth B VLT-UT3 (Melipal)
Opto-mechanical layout	4 beams, each a complete focal-reducer, F/1.88 output
Wavelength coverage	0.37 to 1 microns
Detectors	$4 \times 2048 \times 4096$, 15 μm/pixel Deep-depletion E2V 44-82 (new)
Spectral Resolution	$R = 180$ to 2500 (1 arcsec slit)
Filters	10 per channel, *U'BVRIz*, OS-red, OS-blue, GG435, GG475, 170mm diameter
Grisms	6 per channel, LR red, LR blue, MR, HR blue [1], HR orange, HR red [2]
Flexures	Active[3] compensation: positioning accuracy <0.3 pix during acquisition
Masks	10 masks simultaneously loaded in instrument (practical) maximum (per channel) [4]. Slits of any position and shape, width $> 0.6''$, length < 30".
Multiplex	840 simultaneous slits, 10" long at R = 200 210 simultaneous slits, 10" long at R = 2000-2500
Integral Field Unit	$54'' \times 54''$ field, 6400 fibers with $0.67''$ sampling $27'' \times 27''$ field, 6400 fibers with $0.33''$ sampling

[1] In March 2012 a new set of HR blue VPH grisms were installed. Their peak efficiency is ≈25% compared to 15% with the old grisms. The old grisms are not available any more. [2] From October 2005, a set of four new and more efficient HR red VPHG grisms is installed and available in the 4 channels.
[3] The value quoted is the precision with which we can center a reference fiber in each quadrant. The reference fiber is attached to the frames that hold the masks in place. Thus, the motion of the masks is larger than this by an amount yet to be determined, but close to 1.5 pix peak-to-valley.
[4] Some restrictions apply in operations; currently the number of user masks that can be mounted at the instrument cabinet is 8 as 2 slots are used by calibration masks. Please refer to the VIMOS web pages for updates.

channel is equipped with a new deep depletion, E2V 44-820-1-D42 device (henceforth new CCDs), with exactly the same format but with higher throughput in the red and reduced fringing. The 4k pixels are arranged along the dispersion direction to maximize the spectral coverage. VIMOS is installed on the Nasmyth B focus of UT3 (Melipal). The VIMOS mechanical and optical characteristics are summarized in Table 2.1.

A schematic optical and opto-mechanical layout is shown in Figs. 2.1 and 2.2.

- The focal plane is divided in 4 identical channels and is equipped with: the mask exchange units (MEU) which host up to 8 pre-punched masks for MOS spectroscopy per quadrant; the IFU fiber-head, and the IFU masks.
- The Focal Plane Adaptation Lens (FPAL) reduces field curvature from 2m to 4.1m; partially corrects astigmatism; and make the the field curvature concentric with the new exit pupil;
- The Pupil Relay Lens (PRL), correct for pupil chromatism in combination with FPAL, and is the first element of the collimator;
- The folding mirror section hosts the four folding mirrors and the active flexure compensation system (AFC).
- The Filter/Camera Section: the beam section hosts optical analyzers (filters and/or grisms), the camera, and the exposure shutter in front of the CCD.

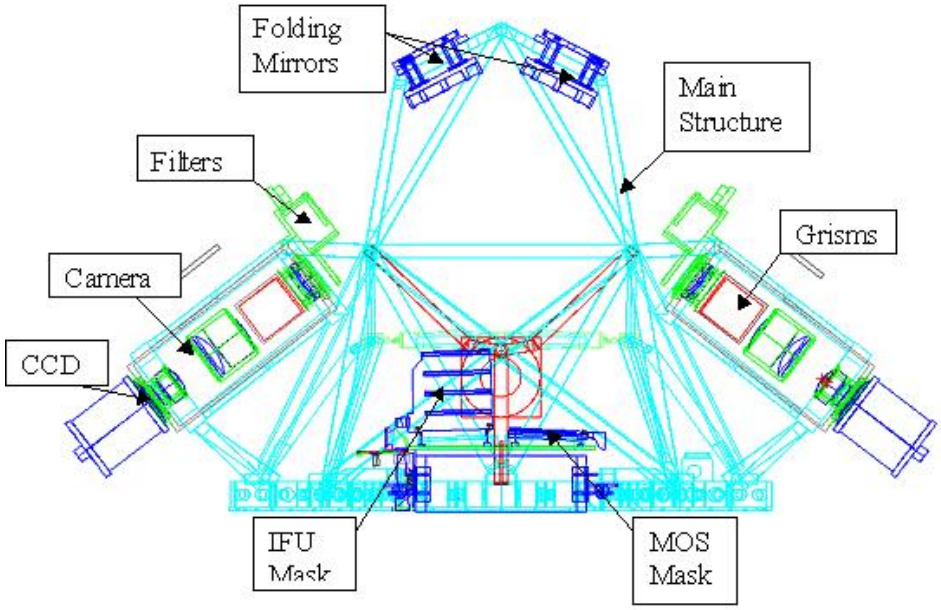


Figure 2.2: VIMOS Opto-Mechanical layout

- FEU: the filter exchange units (one for each channel) are located below the main body of the instrument below the Filter/Camera Section; each unit hosts a juke-box of 10 filters permanently mounted.
- GEU: the grism exchange units are located below the Filter/Camera Section; they host a carousel of six grisms permanently mounted.

2.1.1 Instrument modes

VIMOS offers the following modes for observations:

- Imaging (IMG) (see Sect. 2.2)
- Multi-Object Spectroscopy (MOS) (see Sect. 2.3)
- Integral Field Spectroscopy (IFU) (see Sect. 2.4)

IMG mode uses broadband filters *U'BVRIz*. MOS and IFU modes share the set of grisms and order sorting filters given in Table 2.5. In MOS mode, a set of four laser punched masks made of INVAR is inserted in the focal plane. In IFU mode, fibers are arranged along pseudo-slits in the so-called "IFU masks". IFU masks may be inserted in the instrument focal plane (in the same position as occupied by the INVAR masks in the MOS mode). The spectral characteristics of the two spectroscopic modes are therefore similar, but not identical.

2.2 Imaging

Direct imaging is used to produce wide field images (VIMOS is the largest imager on the VLT) using broad band filters. This mode has two functions: produce science images, and produce the mandatory pre-images needed to prepare masks (see Sect. 3).

Table 2.2 summarizes the main characteristics of the imaging mode.

Table 2.2: VIMOS Imaging characteristics and performance

Field of view	$4\times7' \times 8'$ separated by 2' gaps illuminated CCD area: 2048×2350 pix^2 slightly vignetted on the corners outside 8'
Pixel scale	0.205"/pixel
Image Quality	80 % encircled energy in 0.4" within the whole field
Filters	U', Bessel *BVRI*, Gunn z (see section A)
F-ratio	1.88
Limiting Magnitudes in 1h[1]	U=26.2 B=27.4 V=27.0 R=26.6 I=25.5 z=25.1

[1] 5σ detection for an A0 star

2.2.1 IMG mode: orientation of the field of view

Figure 2.3 shows the orientation of the instrument field of view. At 0° rotator angle the x axes of the CCDs are oriented E and the y axes are oriented N (top panels). Increasing rotator angle moves the compass counterclockwise. At 90° rotator angle the x axes are oriented S and the y axes are oriented E (bottom panels). Note that position angle increases as rotator angle.

Figure 2.4 shows the instrument FoV keeping fixed the detectors with x axes increasing to the right, and y axes increasing to the top. Top right panels refer to the situation with the rotator at 0°, and bottom right panels refer to the situation with rotator at 90°. The corresponding positions of the detectors on sky are shown in the left panels.

The gap between the quadrants is approximately 2'. The pointing coordinates correspond approximately to the center of the gap.

2.2.2 Image Quality

For the most updated information please have a look at the Quality Control and Data Flow Operations Web pages.

The focal plane of VIMOS is not strictly flat because of the complexity of the optical elements involved. This results in slight focus variations across the field, which translates in a variable PSF from the center to the periphery. The sky concentration effects are in any case small and negligible for flat-field and photometric calibrations.

2.2.3 Imaging Filters

VIMOS provides positions for 10 broadband filters in any of the four channels. Presently installed filters inside the instruments are U', Bessel *BVRI*, Gunn z, and some order separation filters. Only the *U'BVRIz* filters are available for imaging programmes. The special U' is not a standard Bessel filter (see Figure A.1). With the Bessel I and Gunn z filters the CCDs show no fringes.

The complete list of filters together with the transmission curves are presented in Appendix A (see Table A.1, and Figs. A.1 to A.4).

ESO will not accept requests for user's supplied filters for VIMOS.

2.2.4 Zero points

The measured zero points with the new detectors, referred to airmass 1, are given in Table 2.3. We have estimated isophotal magnitudes and effective wavelengths for Vega, and are given in Table 2.4, together with the expected zero points.

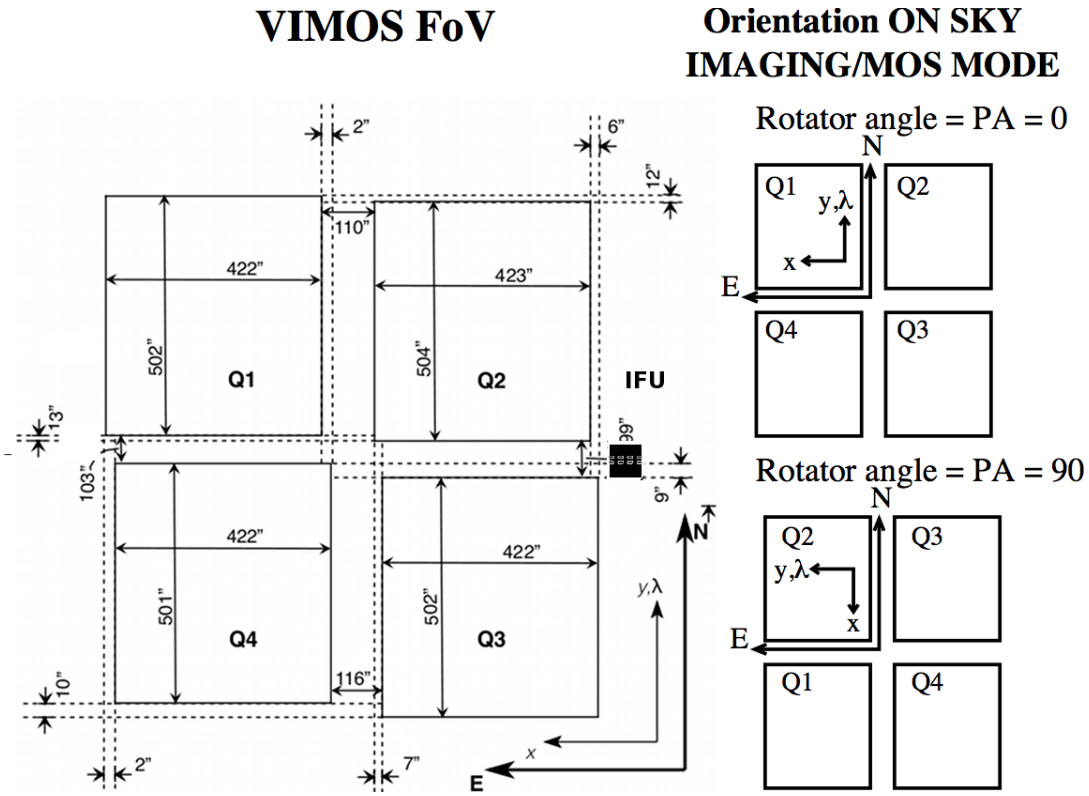


Figure 2.3: Orientation of the VIMOS field of view on sky for position angles 0° and 90°, in IMG and MOS mode. Uncertainties, due to the poorly defined distortion solution at the very edges of the detectors and the fact that the edges are not straight when projected onto the sky, are of the order of 1" (5 pixels). Distances are not shown to scale, refer to the given values.

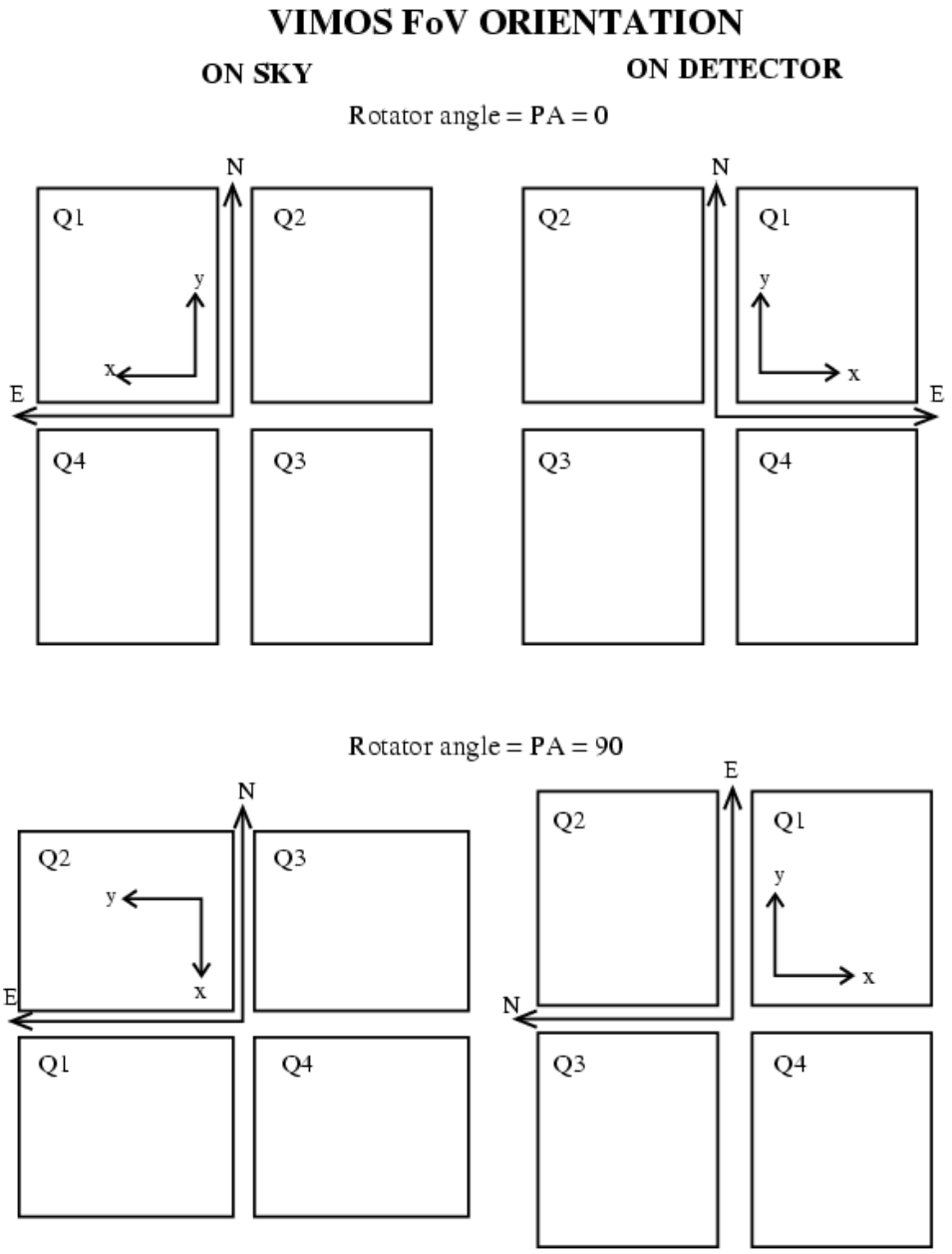


Figure 2.4: A comparison of the orientation of the VIMOS field of view as seen on sky (left panels) and on detector (right panels) for position angles 0° and 90°, in IMG and MOS mode.

Table 2.3: Measured imaging zero points

Filter	Q1	Q2	Q3	Q4
U	26.18	26.12	26.38	26.38
B_{BESS}	28.13	28.12	28.18	28.25
V_{BESS}	27.88	27.79	27.91	27.85
R_{BESS}	28.00	27.92	28.02	27.99
I	27.70	27.57	27.76	27.63
z_{Gunn}	-	-	-	-

Table 2.4: Calculated isophotal fluxes and wavelengths

Filter	$\lambda_{iso}^{(1)}$	$F_{\lambda}^{(1)}$	Expected zero point	$\lambda_{1/2}^{(2)}$	$\Delta\lambda^{(3)}$
	nm	W m^{-2} μm^{-1}	mag	nm	nm
U	378.0	4.89E-08	26.25	370.9	42.1
B_{BESS}	431.2	6.51E-08	28.10	431.3	96.0
V_{BESS}	544.1	3.63E-08	27.80	547.5	86.7
R_{BESS}	639.8	2.19E-08	27.98	646.3	133
I	814.2	1.06E-08	27.60	828.7	186
z_{Gunn}	900.2	0.83E-08	26.79	935.5	178

(1) For Vega, as defined in Tokunaga and Vacca PASP 117, 421 (2005).
(2) Wavelength at which half the transmission is at shorter wavelengths (filter profile only).
(3) Band width, as defined by the distance between the half transmissions (filter profile only).

2.3 Multi-Object Spectroscopy (MOS)

A variety of grisms with different wavelength ranges and dispersions is available in MOS mode. Order separating filters are available to eliminate the overlap, *for a given slit*, between orders 1 (the order used for science) and order 2 (always present on the detector). This is done by restricting the wavelength range of a particular grism to less than one octave in wavelength. The 0th order contamination is present only in multi-layered mode, i.e., when observing with the LR and the MR grisms.

Table 2.5 indicates the recommended and allowed grism + filter combinations. **Any other combinations of grisms and filters should be requested with a waiver**. Defining in the OBs combinations not allowed and for which a waiver was not requested will result in these OBs being rejected by the User Support Department.

ESO will not accept requests for user's supplied grisms or filters for VIMOS.

Table 2.5: Standard grism / filter combinations for MOS and IFU modes

Grism	Filter	
	Default	Allowed
LR blue	OS-blue	Free
LR red	OS-red	Free
MR	GG475	OS-red, OS-blue[1]
HR blue	Free	–
HR red	GG475	–
HR orange	GG435	–

[1] The grism-filter configuration MR+OS-blue is not supported by the pipeline

Transmission curves are available in Appendix A for the filters, and Appendix B for the grisms.

Table 2.6 shows the spectral range covered in MOS modes by the various grisms, as obtained by the automatic pipeline when reducing the spectrophotometric standard star. This spectral range is valid for slits close to the center of the field.

2.3.1 Spectral range

In MOS mode, slits can be positioned at any position in the imaging field of view. With high-resolution grisms, the observed spectral range changes slightly according to the position of the slit. Table 2.7 shows the spectral ranges covered by the detector for each grism (and default order sorting filter) for the slits located at three different positions in the field of view. With low resolution grisms, the spectral coverage is independent of the position of the slit.

2.3.2 Spectral resolution

The spectral resolution obtained with a 1" slit width with the various grisms is given in Table 2.6.

2.3.3 Multiplex characteristics

A particular feature of the MOS mode is the possibility of stacking multiple layers of slits along the dispersion direction. This is only possible with the low resolution grisms (up to four slits along the dispersion direction) and the intermediate resolution grisms (up to two slits), for which the spectra are short enough (in number of pixels) to allow stacking. With the high-resolution grisms, only one slit can be placed along the dispersion direction.

Table 2.6: MOS: spectral resolution and spectral ranges observed using the mask for spectrophotometric standard stars

Grism	Default Order sorting filter	Spectral range	Number of pixels	Undeviated wavelength (nm)	Spectral Res. (1" slit)	Dispersion (Å/ pixel)	Spectral multiplex
LR_blue	OS-Blue	370-670 nm	550	480	180	5.3	4
LR_red	OS-Red	550-950 nm	550	750	210	7.3	4
MR	GG475	480-1000 nm	2000	700	580	2.5	2
MR	OS red	550-970 nm	2000	700	580	2.5	2
HR_blue^{NEW}	Free	370-535 nm[1]	2324	402	1150	0.71	1
HR_blue^{OLD}	Free	415-620 nm[1]	4096	510	2050	0.51	1
HR_orange	GG435	520-760 nm[2]	4096	631	2150	0.6	1
HR_red[4]	GG475	630-870 nm[3]	4096	740	2500	0.6	1

[1] New VPH HR_blue grisms are in use since March 2012. The old grisms are not available any more. Their characteristics are given here for comparison purpose. The spectral resolution for the HR_blue grism is for the undeviated wavelength, 402 nm. Notice that for the old HR_blue grism the resolution was measured at 587.5 nm. At this wavelength we have for the new VPH HR_blue R≈1680. The wavelength range for the new grism is given for a slit at position y=1220 in acquisition image in Q1 and is common for all quadrants.
[2] With HR_orange grism the spectral range in quadrant 1 (for a standard star) is 505-745 nm
[3] With HR_red grisms the spectral range in quadrant 1 (for a standard star) is 650-865 nm
[4] New HR_red VPHG grisms have been installed from October 5, 2005.

However, please note that in the multi-layer mode there is some order overlap: the second order of one slit may overlap with the first order of the adjacent slit. There is also 0^{th} order contamination between different layers of slits.

For faint objects, order overlap is usually not a problem: only the sky will contribute significantly to the overlap, with a contribution that cannot be distinguished from the first order. This however constrains the positioning of the slits in the focal plane: stacked slits along the dispersion direction have to be strictly parallel and of the same length to allow the second orders to overlap nicely with the first order of the adjacent slits.

With the low-resolution grisms, the use of *no filter* instead of the default order sorting filters OS-blue and OS-red will result in longer spectra and second order overlap. It is **strongly recommended to reduce the multiplex/number of slits along the dispersion direction** to avoid/reduce multiple overlaps. The multiplex can be reduced by increasing the distance between slits.

2.3.4 MOS mode: orientation of the field of view

The orientation of the instrument field of view in MOS mode can be inferred from Figs. 2.3 and 2.4, taking into account that not tilted slits are oriented along the x-axes, and that wavelength dispersion is along the y axis, with wavelength increasing with y.

2.4 Integral Field Unit (IFU)

The Integral Field Unit (IFU) is a dedicated opto-mechanical system aimed at producing spectra of a contiguous area of up to 54 × 54 arcsec^2. For VIMOS set at PA=0° the center of the FoV of the IFU is located approximately 667″due west, and 1.6″due south of the VIMOS center field (See Fig. 2.3). The sky image is projected onto a micro-lens array with a choice of two spatial samplings (magnifications): 0.33" or 0.67" per resolution element (fibre). Each 2D input micro-lens is coupled to an optical fiber. The output of the fibers is re-arranged on a linear set of micro-lenses to produce an entrance slit to the spectrograph, at the mask focal

Table 2.7: Spectral coverage $\Delta\lambda$ for three positions of the slit in field of view (MOS mode)

Grism	Order sorting filter	$\Delta\lambda$ CCD center	$\Delta\lambda$ CCD bottom	$\Delta\lambda$ CCD top
LR red	OS-red	550 - 950 nm	550 - 950 nm	550 - 950 nm
LR blue	OS-blue	360 - 670 nm	360 - 670 nm	360 - 670 nm
MR	GG475	500 - 1000 nm	500 - 1000 nm	500 - 950 nm
HR blue^{NEW}	Free	370 - 535 nm[1]	370 - 624 nm[1]	370 - 451 nm[1]
HR blue^{OLD}[2]	Free	370 - 552 nm	468 - 674 nm	370 - 566 nm
HR red	GG475	630 - 870 nm	690 - 930 nm	570 - 805 nm
HR orange	GG435	520 - 760 nm	577 - 817 nm	463 - 703 nm

[1] HR_blue^{NEW} The ranges correspond to Q1 for slits positioned at y=50, 1220, and 2390 in the acquisition image for the bottom, center, and top ranges, and it is common to all quadrants. For other quadrants visit the VIMOS web pages.
[2] HR_blue^{OLD} not available after March 2012. Info given for reference.

plane location. Each IFU mask (one for each channel of VIMOS) has a set of 4 fibre-slits (or pseudo-slits), for a total of 6400 fibers.

2.4.1 IFU mode: orientation of the field of view

Figure 2.5 shows the orientation of the instrument field of view in IFU mode for the four quadrants. On the detectors, wavelength dispersion is along the y axis, with wavelength increasing with y. An actual example for PA=0° is shown in Fig. 2.6. The increasing position angle on the sky (east of north) corresponds to the positive rotator angle. Spatial characteristics are described in the Section below.

As for IMG/MOS modes, the pointing coordinates in the header correspond to the center of the VIMOS field of view. Due to the offset position of IFU with respect to the center, the keywords RA and DEC in the headers do not refer to the IFU pointing, but rather to the center of the VIMOS FoV. Prior to P91 the only way to determine the actual position of the IFU was using the center coordinates, together with the IFU offset position, coded in the keywords "HIERARCH ESO OCS CON WCS IFUCENX", and "HIERARCH ESO OCS CON WCS IFUCENY", and the PA on sky (after some spherical trigonometry). This was needed because the only other relevant information on the headers was "HIERARCH ESO TEL TARG ALPHA", and "HIERARCH ESO TEL TARG DELTA", which contained the coordinates of the target. Any offsets from the original pointing would result in an IFU pointing that would differ from these keywords. Starting in P91 the relevant header keywords which contain the information of the actual pointing of the IFU are "HIERARCH ESO INS IFU RA" and "HIERARCH ESO INS IFU DEC". Notice that the whole ESO archive of IFU data has been retro-fitted with these keywords, so now it is possible to search for IFU observations simply queryng by target coordinates.

2.4.2 Fiber arrangement and spatial characteristics

The special arrangement of fibers for VIMOS IFU head is shown in Fig. 2.7. The fibers numbering has been arranged following the scheme: mask - line - module -fiber (i.e. 4 - B - 5 - 67). The arrangement of the fibers into the 4 pseudo-slits mask (one for each channel) is reported in Fig. 2.8. The detailed IFU table is distributed to the users together with the data release.

A masking-shutter (IFU shutter) is provided in front of the input micro-lens array; this allows the exclusive use of the central 1/4$^{\rm th}$ of the field when IFU is used with intermediate and high spectral resolution grisms. In this configuration, only 1 fiber-slit per quadrant (mask) is used, for a total of 1600 fibers. The templates for IFU mode offer the option to insert a shutter to limit the field to the central part also for low resolution grisms.

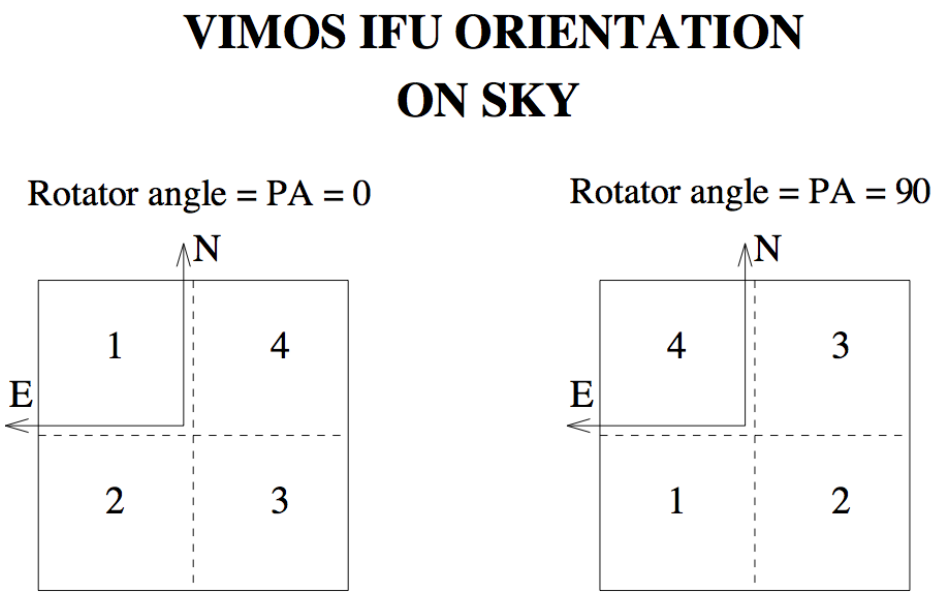


Figure 2.5: Orientation of the VIMOS IFU field of view on sky for position angles 0° and 90°, in IFU mode.

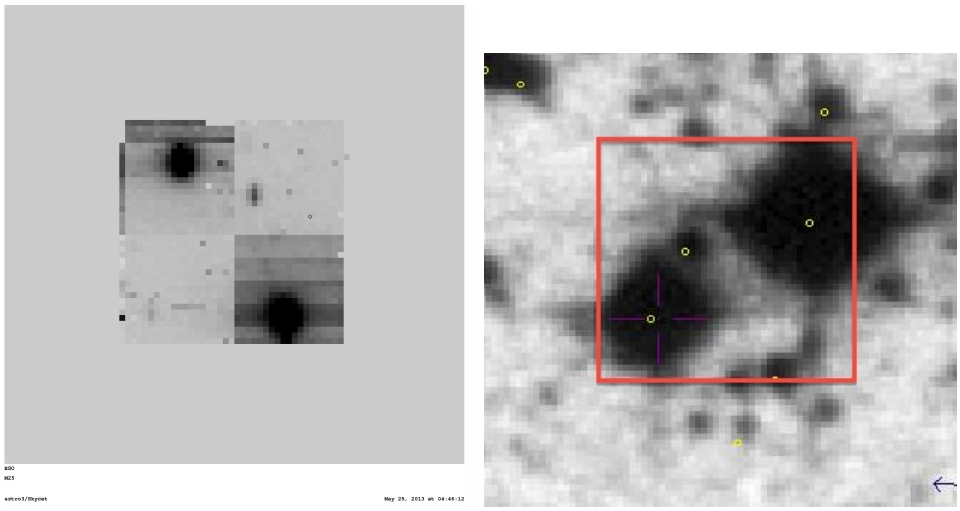


Figure 2.6: (a, left) Image of M25 showing the IFU field of view for position angle 0°, after pipeline reconstruction. Notice the quadrant ordering starting from top right, counterclockwise: Q1, Q2, Q3, and Q4. (b, right) The same field with North up and East to the left from the DSS. The total FoV is approximately 1 arcmin for both images.

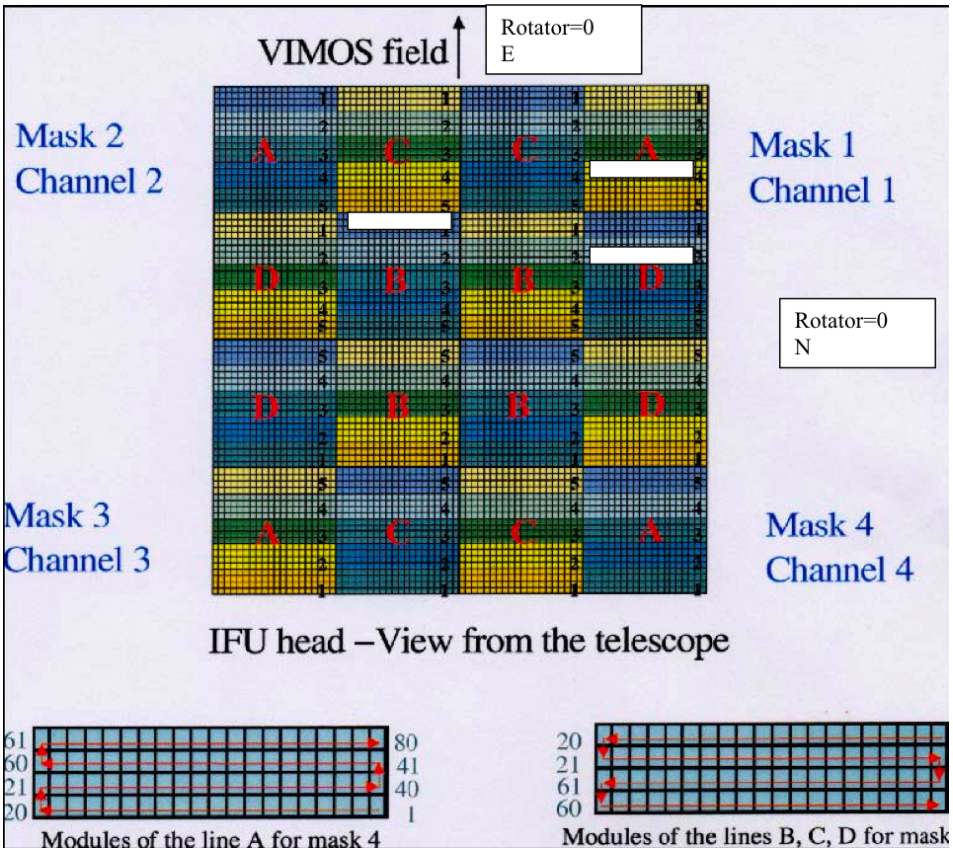


Figure 2.7: IFU head: details of the fiber modules. Low transmission fiber blocks are marked with white rectangles. For rotator angle = 0°, North is to the right, East to the top.

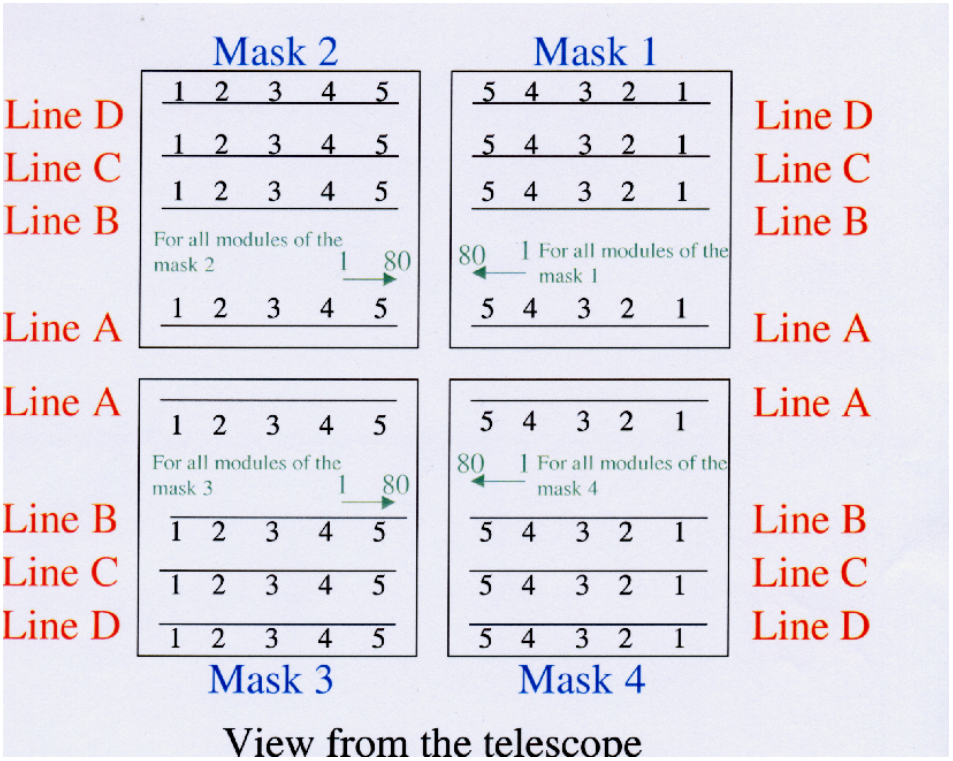


Figure 2.8: IFU mode: fibers numbering on the masks

Table 2.8: Integral Field Unit: spatial characteristics

Grism	Shutter	Spatial sampling (arcsec/fibre)	Field of view arcsec^2	Number of fibres	Pseudo-slits per quadrant
LR blue, LR red	OFF	0.67”/fibre	54” x 54”	80 x 80	4
LR blue, LR red	ON	0.67”/fibre	27” x 27”	40 x 40	1
LR blue, LR red	OFF	0.33”/fibre	27” x 27”	80 x 80	4
LR blue, LR red	ON	0.33”/fibre	13” x 13”	40 x 40	1
MR, HR blue, HR orange, HR red	ON	0.67”/fibre	27” x 27”	40 x 40	1
MR, HR blue, HR orange, HR red	ON	0.33”/fibre	13” x 13”	40 x 40	1

When small field can be accommodated, this avoids second order contamination by the sky or background objects from the 3 pseudo-slits corresponding to the outer part of the field of view.

Table 2.8 shows the spatial characteristics of the IFU mode.

2.4.3 Spectral range

Table 2.9 shows the spectral range covered in IFU modes by the various grisms, as obtained by the automatic pipeline when reducing the spectrophotometric standard star.

With low and intermediate resolution grisms the spectral coverage is independent of the position of the IFU pseudo-slits. With the high-resolution grisms, the spectral coverage is determined also by the (fixed) positions of the pseudo-slits in the focal plane, but it varies slightly from quadrant to quadrant. The spectral coverage for each quadrant derived from the automatic reduction of standard star observations with VIMOS pipeline is listed in the Table 2.10.

2.4.4 Spectral resolution

In IFU mode, spectral resolution is fixed by the combination grism + fiber size (the fiber FWHM is about 3.2 pixels, corresponding to 0.67”). The spectral resolution is about 1.25 times the spectral resolution obtained in MOS mode with a 1” slit width. The spectral resolution for various grism+filter combinations is given in Table 2.9.

2.4.5 Multiplex characteristics

The same multiplex capability described in MOS mode is also used in IFU mode. With the low-resolution grisms there are 4 pseudo slits of fibers along the dispersion direction. With intermediate and high-resolution grisms only the central pseudo-slit is used (in practice by masking the entrance field of the IFU so that the other pseudo-slits do not receive sky light).

Table 2.9: Spectral characteristics in IFU mode

Grism	Default Order sorting filter	Spectral range common to all quadrants	Spectral Res. (0.67" fiber)	Dispersion (Å / pixel)	Spectral multiplex
LR_blue	OS-Blue	400-670 nm	220	5.3	4
LR_red	OS-Red	590-915 nm	260	7.3	4
MR	GG475	490-1015 nm	720	2.5	1
HR_blue^{NEW}	Free	370-535 nm	1440	0.71	1
HR_blue^{OLD}	Free	415-620 nm	2550	0.51	1
HR_orange	GG435	525-740 nm	2650	0.6	1
HR_red	GG475	645-870 nm	3100	0.6	1

Note: new HR_red VPHG grisms have been installed in October 5, 2005.
Note: New VPH HR_blue grisms are in use since March 2012. The old grisms are not available any more. Their characteristics are given here for comparison purpose. The resolution for the new VPH HR_blue grism is given for the undeviated wavelength of 401.6 nm, which corresponds to 2100 at 587.5 nm, the wavelength for the old grism R value.

Table 2.10: IFU: spectral coverage in the various quadrants

Grism	Q1	Q2	Q3	Q4
LR_blue + OS blue	390 - 670 nm	395 - 675 nm	400 - 680 nm	400 - 680 nm
LR_red + OS red	570 - 915 nm	580 - 930 nm	590 - 930 nm	585 - 930 nm
MR + GG475	485 - 1015 nm	490 - 1020 nm	490 - 1020 nm	490 - 1015 nm
HR_blue + free	370 - 537 nm	370 - 535 nm	370 - 550 nm	370 - 563 nm
HR_orange + GG435	525 - 745 nm	525 - 745 nm	525 - 745 nm	525 - 740 nm
HR_red + GG475	635 - 860 nm	635 - 865 nm	635 - 860 nm	645 - 875 nm

2.5 Detectors

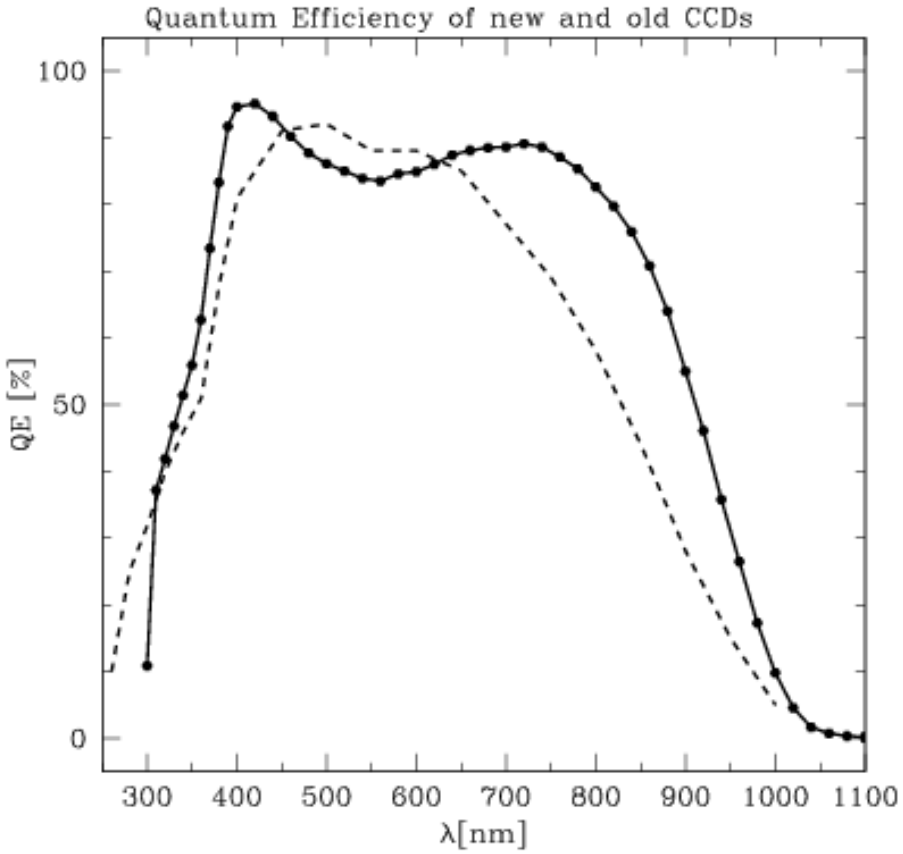


Figure 2.9: QE curves of the new (thick line) and old (dashed line) VIMOS CCDs. Notice that the QE of the new CCDs correspond to a single detector (Tom).

2.5.1 Detector system

Since August 1st 2010 VIMOS has four new red-sensitive detectors. They are E2V CCD-44-82-1-D42, back-illuminated, non-inverted mode operation, deep-depletion devices. The new devices have exactly the same format as the old ones, that is, 2k×4k. Their main difference compared to the old ones is an increased quantum efficiency in the red and reduced fringing. The response of the new detectors is comparable to the old ones in the range 400-600 nm where it starts to increase, reaching a factor of two improvement at approximately 850 nm. At the U-band there is a loss of 30% Please check the VIMOS news pages and/or contact ESO's User Support Department for further news.

Table 2.11 indicates the basic characteristics of the VIMOS CCDs. Figure 2.9 shows the quantum efficiency curve of one of the CCDs.

Detector read-out modes and format

The CCDs have two read-out ports but only one is used. This increases the read-out time but, as a benefit, the gain, offset, and read-out noise are constant along the entire CCD.

In spectroscopic mode, the full CCDs (2048×4096 pixels^2 are read-out; in imaging mode, readout is windowed to 2048×2400 pixels^2. In fact, in both spectroscopic mode and in imaging mode, the CCDs are

Table 2.11: Basic characteristics of the new VIMOS CCDs

Parameter	Value
Number of pixels	2048×4096
Pixel size (μm)	15
Dark current at –120° C (e^-/px/h)	<7
Deviation from Linearity (Full well; %)	< 0.5
Charge transfer efficiency	>0.999995

vignetted by some hardware. In spectroscopic mode, the illuminated area is about 1970×4096 pixels[2], and in imaging mode the illuminated area is about 1970×2300 pixels[2]. The actual values depend on the individual CCDs. The default readout modes are indicated in Table 2.12.

Table 2.12: New Detector System Readout Modes and Characteristics[1]

VIMOS Mode	Size	Speed	Binning	Gain	Port	Windowing	Readout time
Imaging	4×2k×2k	225kpx s^{-1}	1×1	Low	1-port	Not supported	1 m
Spectroscopy	4×2k×4k	225kpx s^{-1}	1×1	High	1-port	Not supported	1 m

[1]The old detector system had exactly these same modes.

Controllers

The 4 CCDs are controlled by two FIERA controllers. The detectors of channel 2 and 3 are controlled by FIERA A (VIMOSA), the detectors of channel 1 and 4 by FIERA B (VIMOSB).

Read-out noise and conversion factor

Table 2.13 indicates the readout noise and gain values for the 4 chips. Note that these values are subject to change and are indicated here only for reference. Exact values to be found in the image headers under the following keywords: HIERARCH ESO DET OUT1 GAIN, and HIERARCH ESO DET OUT1 RON (the number x in OUTx could change depending on the output amplifier used).

Table 2.13: New detectors read-out noise and conversion factors. For reference only, subject to change

Chip	Read-out Mode	RON [e$^-$ rms]	K [e$^-$/adu]
CCD 1	225 kpx s^{-1}, low gain (IMG mode)	3.9	1.76
CCD 2	225 kpx s^{-1}, low gain	3.8	1.79
CCD 3	225 kpx s^{-1}, low gain	3.6	1.79
CCD 4	225 kpx s^{-1}, low gain	3.6	1.71
CCD 1	225 kpx s^{-1}, high gain (MOS/IFU)	3.2	0.53
CCD 2	225 kpx s^{-1}, high gain	3.1	0.55
CCD 3	225 kpx s^{-1}, high gain	3.1	0.56
CCD 4	225 kpx s^{-1}, high gain	3.1	0.54

RON and conversion factor monitoring is available through the QC1 WEB pages

Fringing

The new detectors have substantially reduced fringing - it is negligibly small in I and z-band imaging mode. In spectroscopic mode there is some residual fringing that depends on the slit width and grism used: for a $1''$slit fringing at 900nm is only 1% in the high resolution grating (growing in nearly a linear fashion with the inverse of the slit width). For the low resolution grating it is not detectable.

Red leaks

With CCDs with much higher sensitivity in the red the issue of red leaks needs to be studied with care. Imaging observations with the U or B filter might be affected to a degree still to be determined.

New shutters

As part of the VIMOS upgrade project a new set of bi-stable shutters, i.e. they do not draw current in the open nor in the closed position, has been installed. The exact properties of these shutters, i.e. shutter delay, still need to be determined.

The shutter (one for each CCD camera) guarantees uniform illumination of the CCD to the 1 % level or better for exposure times as short as 1 sec (the shortest possible exposure time).

2.5.2 More information

More (updated) information on detector characteristics, cosmetics, and performance on sky at:

http://www.eso.org/sci/facilities/develop/detectors/optdet/instruments.html
http://www.eso.org/observing/dfo/quality/

2.6 Calibration Units

VIMOS has three calibration units illuminating a calibration screen at the back of the Nasmyth shutter (closing the Nasmyth tunnel).

Each unit has the following lamps:

- Flatfield lamps:
  - QTH10 halogen lamp for imaging screen flats in *VRIz*, and MOS spectroscopic screen flats in LR red and blue
  - QTH50 halogen lamp for imaging screen flats in *U'B*, MOS screen flats in MR, HR red and blue, and all IFU screen flats
- Arc lamps:
  - He
  - Ar
  - Ne

In the web an updated atlas of spectral lines for the different grisms can be found.

2.7 AFC: Active Flexure Compensation

Since 1st August 2010 VIMOS counts with an active flexure compensation system (AFC). With this system we can position the the image of the FoV onto the detectors to better than 0.3 pixels at the start of the exposure in all quadrants, and maintain it there to within ≈1.5 pixels for the duration of a typical exposure. Previously VIMOS had astatic compensation systems installed only in quadrants 2, 3, and 4. Image motion due to instrument flexures under gravity were approximately 4 pixels peak-to-valley for the channels 2, 3 and 4, and 6 pixels peak-to-valley for channel 1 (for the whole rotator range).

With the new AFC we can control flexures to better than ≈1.5 pixels peak-to-valley, for the range of A/R rotations in typical exposures.

2.8 Known shortcomings of the instrument

VIMOS problems, issues and hints related to data reduction and observations are summarized on the VIMOS QC page:

http://www.eso.org/observing/dfo/quality/VIMOS/ServiceMode/ServiceMode.html#problems

Here we list some shortcomings that should be be kept in mind when planning the observations.

2.8.1 IFU masks vignetting in IMG and MOS mode

When using VIMOS in IMG or MOS mode the IFU masks are stowed. The mechanism that hold the heavy masks in place have some play and, depending on rotator angle, they could be seen vigneeting the FoV. When stowed the IFU masks are folded into the center of VIMOS, that is, the area between Q1/Q4 and Q2/Q3. The hinge is near the focal plane while the far end of the masks are approximately 27 cm from the hinge, into the instrument. The quadrants to be mostly affected depends on the rotator angle. The areas likely to be vignetted have Y pixels $<$200 in Q 1 and 2 and $>$2200 for Q3 and Q4. To ensure that no MOS slits are vignetted users should not place slits in the area likely to be vignetted.

2.8.2 IFU fringing

There is interference produced by internal reflexions in the IFU unit which origin is not completely understood. For details see:

Jullo et al. (2008) ,
Lagerholm et al. (2012) .

The fringing is nearly zero at 400nm and progressively increases to longer wavelengths.

This problem will probably remain for the life of the instrument.

2.8.3 [SOLVED] Non-optimal focus for some grisms

It has been found that the optimal focus depends on what grism is in the light path. This means that spectroscopic observations have not been carried out with the optimal focus. This situation has been solved since March 2012. Starting in April 2012 the instrumental focus is corrected depending on which grism is in the light path.

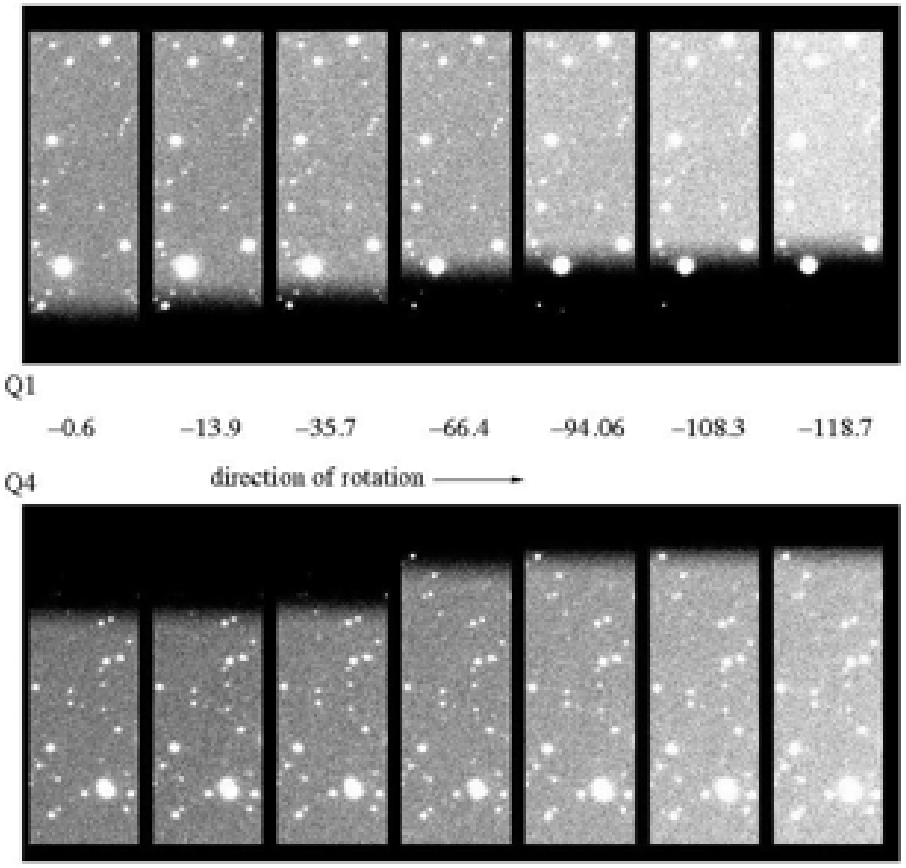


Figure 2.10: Vignetting of the IMG FoV by IFU masks flexures as a function of absolute rotator angle.

2.8.4 [SOLVED] Defocusing at some adapter angles

The focusing mechanisms, specially that of Q3, suffers from flexures which are particluarly large at some adapter rotator angles. This has resulted in a defocus which affects image quality and, in spectroscopic modes, resolution. The degradation can reach 10-20% larger FWHM in IMG, or a 20-30% decreased resolution R in MOS or IFU, at absolute A/R angles of $\approx 116 \pm 50$ degrees.

Starting 1st April 2012 we correct focus for A/R angle and the above situation has been much alleviated.

2.8.5 [SOLVED] IFU focusing issues

It has been found during the March 2012 focus improvement intervention that the focusing range of the VIMOS camera did not allow for proper focusing of the IFU units for all temperatures in the normal range for Paranal (5-20 °C). The defocusing is particularly bad when temperatures go above 10 degrees. An intervention to improve this was successfully carried out in Q4 2012. This defocusing was there since the start of operations.

2.8.6 Spectrum rotation

The blocking mechanism of the grism units, the mechanism that fix the grism in place, is not perfect and allow for some spectrum rotation as a function of A/R angle. The peak-to-valley effect depends of the particular grism used, but for a whole rotation of the A/R the spectrum can rotate by 10 pix over 4000 pix.

A redesign of the grism blocking mechanism is under study.

2.8.7 Temperature dependent bias level

Although this is a common problem, for Quadrant 2 the temperature sensitivity is particularly large. We thus strongly recommend to use the overscan region on each image to determine the best bias level to be substracted.

2.8.8 Temperature dependent image scale

During the VIMOS upgrade project we found that the image scale depended on temperature. This is the result of the changing optical configuration needed to keep the instrument in focus at all temperatures, that is, VIMOS is not telecentric. The effect was discovered once we started to use the active flexure compensation mechanism. Every day we take an image of a pinhole mask with the instrument at the same rotation angle. This image is taken after acquiring a reference fiber, located in the instrument frame and not in the pinhole mask, at the edge of the FoV and positioning it at the same pixel position. We found that the position of the central pinhole of the mask depended on temperature. Starting on December 2011 we correct the reference pixel position depending on temperature to counterbalance this effect. With this we can ensure that the central position of the masks do not depend on temperature, but we can not change the effect on scale. Between 5 degrees and 15 degrees the effect was approximately 2 pixels. With the temperature compensation scheme that we have implemented we can expect a maximum shift of only 0.5 pixels for the slits located at the top or bottom of the FoVs.

Chapter 3

Observing with VIMOS

All observations with VIMOS are done via "observing blocks" (OBs). OBs consist of one acquisition template including target information followed by "observing templates" related to the observing mode. The users will fill out the parameter fields ("keywords") of the templates (e.g. grisms, filters, etc). All the preparations are done with the Phase II proposal preparation tool p2pp.

In addition, VIMOS masks have to be prepared with the VIMOS mask manufacturing preparation software VVMPS.

The strategy behind observing blocks and templates is to prepare the observations well in advance to minimize any interactive steps during the observations (optimization and service mode compatibility). The execution of the OBs will be mostly automatic and the execution will be done by telescope and instrument operators and staff astronomers. Direct interaction at execution time is only required for the target acquisition and to assess the quality of the data.

The preparation of visitor and service mode observations requires special care, and the relevant documentation should be consulted. See Sect. 1 for instructions on how to retrieve the corresponding information.

3.1 Interactions with the telescope

3.1.1 Guide stars and Guidecam software tool

For telescope guiding and active optics correction it is necessary to find a guide star of magnitude in the range 11-13.5 within the Nasmyth field of view. The guide star is picked up by the Guide Probe, which is attached to the telescope *adapter*. (Note that the adapter is independent of the telescope *rotator* to which the instrument is attached.)

In IMG and MOS mode, it is not always possible to find a guide star such that the Telescope Guide Probe is not vignetting the VIMOS field of view. Therefore, users are asked to select the guide star for their observations. The choice of the guide star is **mandatory** for pre-imaging, for imaging, and for MOS programs. In fact, the guide star for MOS is selected at the time of pre-imaging: guide star coordinates and position of guide probe (whether positive or negative) is stored in the pre-image headers, and subsequently propagated by VMMPS (see Sect. 3.5.4), the VIMOS Mask Preparation Software, into the Aperture Definition in Pixel (ADP) files. At the time of the MOS acquisition, this information is extracted from the ADP and the same guide star as used for pre-imaging will be re-used for the MOS observations. Only in some exceptional cases, the telescope operator may have to select another guide star: see Sect. 5.6. Users need not select the guiding star for observations carried out in IFU mode.

The position and the amount of the vignetting introduced in the field of view by the guide probe can be controlled with the help of the Guidecam software, that allows one to visualize the geometry of the VIMOS field of view and of the Telescope Guide Probe, and allows users to select the guide star most suitable to their observation.

For a tutorial on the use of the Guidecam tool see Chapter 5

3.1.2 Cumulative offsets

For small telescope offsets, the telescope may keep the same guide star. However, observations involving cumulative offsets greater than about 30" often result in significant vignetting of the guide probe, or even in the loss of the guiding star. For these reasons, all dither positions for offset patterns used in the OBs must fit inside a $30'' \times 30''$ size box. If larger offsets are necessary, users need to prepare separate OBs and use appropriate guide star for each of them.

3.1.3 Telescope and Instrument Focus

The telescope focus is automatically set by the active optics system. No intervention is required by the observer. Defocusing of the telescope is not possible during the observations. The instrument focus is corrected automatically for the different thickness of the various filters, and for temperature variations (autofocus).

3.2 Atmospheric Dispersion

VIMOS is not equipped with Atmospheric Dispersion Corrector in none of its modes. The impact of atmospheric dispersion will be mostly noticed in MOS mode. In imaging, some image elongation may be noticed at high airmasses in the U or B band. In IFU, the effect will mostly be noticed with the LR_blue grism and with the $0.33''$/fiber sampling.

In MOS mode, the effects can lead to severe slit losses if some precautions are not taken. To minimize atmospheric dispersion effects at high airmass, and assuming that the observations are performed close to meridian, we have historically requested that the slits be oriented N-S, forcing the rotator angle to be set at 90°. This rotator angle is the default one to be used for pre-imaging, and the same rotator angle will be used during spectroscopic follow-up. The normal VIMOS operational scenario has been to carry out MOS observations as close as possible to Meridian, within $\pm$ 2 hrs. Starting during Period 90 for pre-image based MOS observations, and starting P92 also for PILMOS observations, we have relaxed this constraint as follow: for targets at declinations in the range $-45^\circ < \delta < -5^\circ$ we permit observations with slits oriented E-W, with rotator angle set at 0°, and with HA within $\pm$ 3 hrs from meridian. Notice that increasing the allowed HA range permits observations at higher airmasses, which increases the FWHM of the images, leading also to increased slit-losses. For a full report see Sanchez-Janssen et al. (2012) in the VIMOS web.

More information and simulations can be found on the VIMOS web. Figure 3.1 shows a worst case scenario of MOS observations with LR_blue (spectral coverage 370 – 670 nm) for a field with declination +20°. For details see also Cuby et al. Proc. SPIE 3355, p36-47 (1998). For a different view on the optimal orientation see Szokoly, G. P. A&A 443, 703 (2005).

3.3 Fringing and Flexures

The amount of uncorrected flexures has a number of operational consequences:

- The accuracy of the slit positions determined from pre-imaging depends on the rotator position. This is for the time being one of the reasons why slit widths narrower than 0.6" are not allowed.
- Accuracy of sky subtraction / flat fielding: accuracy of sky subtraction / flat fielding may be limited by flexures. With dithering / jittering sequences, median running sky frames can be built in imaging or spectroscopy allowing accurate sky subtraction and/or flat fielding of the data
- In spectroscopy, arcs and flats are taken during daytime and at constant rotator angle. Depending on the variation in rotator angle between daytime calibrations and night time observations, some flat field residuals and wavelength calibration offsets may be introduced due to the flexures. In order to minimize/eliminate these effects, night time calibrations can be taken with an adequate template (see Sect. 4).

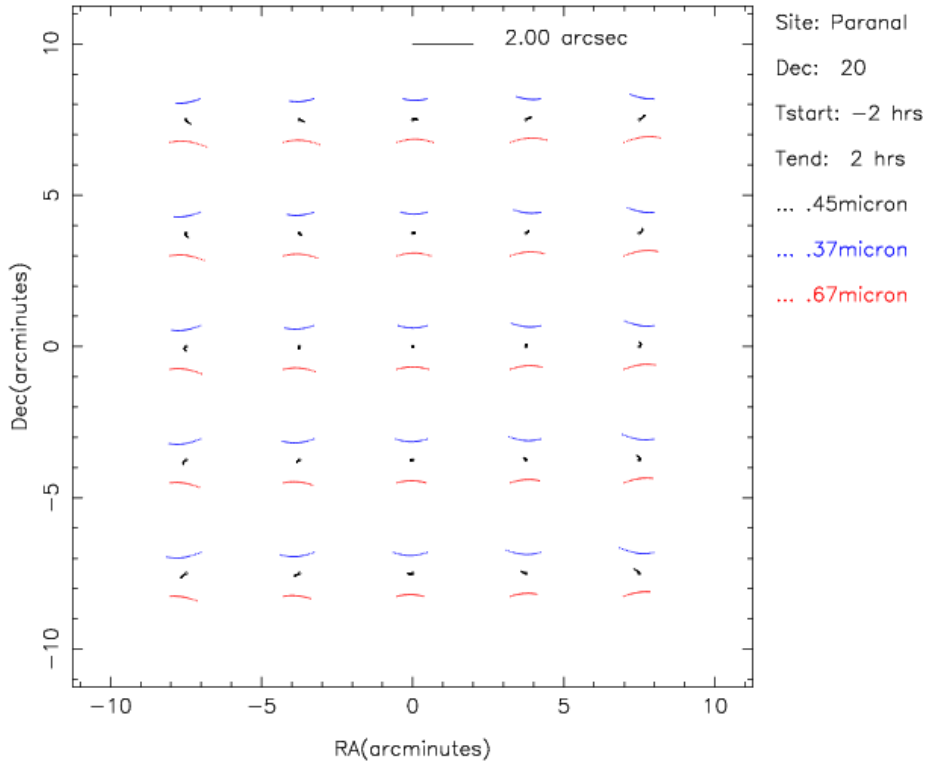


Figure 3.1: Example of atmospheric dispersion at Paranal for a field at declination +20° , observed with the LR_blue grism from ± 2 hrs from Meridian. The blue and red trails show the evolution of the blue and red wavelengths during the exposure. Atmospheric spectra start with N-E orientation and move to N-W through a N-S orientation while crossing the Meridian. The maximum amplitude of the dispersion is ∼ 2" at ± 2 hrs from Meridian. Slits clearly have to be oriented N-S as a default orientation to minimize the slit losses at this declination, assuming that all MOS observations will be carried out within ± 2 hrs from Meridian.

Attached flat and arc calibrations are mandatory for all IFU observations. During the VIMOS upgrade, one attached arc and three flats have also been mandatory for all MOS science observations. The first part of the upgrade, completed by 1st August 2010, included changes of shutters, CCDs, and the installation of the Active Flexure Compensation system. In addition many other mechanical parts are closely monitored. A second part of the upgrade, finished by April 2011, improved image quality and its uniformity accross the field by recentering the cryostats. A third part of the upgrade has been completed during March 2012, and included the exchange of the HR-blue grisms by VPH ones, and a full upgrade of the focusing hardware and software. The last and remaining part of the upgrade took place during Q4 2012 was aimed at improving the focusing range for the IFU mode. All these activities required access to the instrument during the day, which cannot be done if the MOS calibrations are running in the morning. We are analyzing the data to determine in which circumstances night calibrations will be required. Please see the instrument web pages for the latest news.

3.4 Imaging (IMG)

Imaging mode is used for both pre-imaging runs and science imaging runs. In both cases, users are requested to use Guidecam for the selection of guide stars. See Sect. 3.1.1 concerning Guidecam and Sect. 5.6 concerning the policy regarding Guide Stars.

3.4.1 Pre-imaging

Since summer 2012 pre-imaging is no longer mandatory prior to a MOS follow-up, however there are still many types of observation for which it is advisable/essential, see Sections 3.5.1 and 3.5.2.

- **As a consequence of the CCD upgrade, all pre-images taken before the intervention are not valid anymore for MOS follow up observations after the CCD upgrade (i.e. after 31 August 2010).**
- **The use of pre-imaging taken between 31 August 2010 and 24 May 2011 can result in a systematic overall offset affecting all quadrants the same way, but making field acquisition difficult, specially in crowded fields.**

Pre-imaging is carried out in service mode only. The following instructions for preparation of pre-imaging OBs should be strictly followed.

Program ID It is mandatory for Phase I to request a specific pre-imaging run in the proposal form, and for Phase II to prepare the pre-imaging OBs by using the corresponding Program ID.

Filter used The correction of the distortions is derived from R filter observations only. To minimize the slit losses due the distortion of the instrument (which do depend on the filter), the use of the R filter for pre-imaging is mandatory. Although pre-imaging with filters other than R is not permitted, users may request with a waiver to include in the pre-image OB templates with other filters. Note that no waiver will be granted to design MOS masks based on observations done with any other filter but R.

Observation Category: PRE-IMAGE It is mandatory to set the Observation Category to PRE-IMAGE in the observation template VIMOS_img_obs_Offset (see Sect. 4). Failure to do so will result in delays to process and deliver the pre-imaging data, and may result in MOS observations not being carried out.

Standard star requirements Users requesting CLR sky transparency for their pre-images are requested to specify in the README whether they need a photometric standard taken in the same night.

Rotator on sky The rotator on sky, otherwise called position angle on sky, cannot be freely selected by the user. This is in order to minimize the slit losses due to atmospheric dispersion (Sect. 3.2). The default value is 90°, and corresponds to an orientation of the field with E to the top, N to the left (see Fig. 2.3). For declinations in the range -45°$< \delta < -5°$, this parameter can be set to 0°. In *special cases* it may be possible to deviate from these rules *if* there is a valid scientific reason; in that case a waiver must be specifically requested to ESO before you submit your Phase II information. For a full report see Sanchez-Janssen et al. (2012) in the mos section of the VIMOS web pages. and the corresponding 2014 A&A paper.

3.4.2 Science imaging

Observation Category: SCIENCE It is mandatory to set the Observation Category to SCIENCE in the observation template VIMOS_img_obs_Offset (see Sect. 4), otherwise data will be treated as pre-imaging and will not be processed as regular imaging data.

Rotator on sky Users are encouraged, but not forced, to use the default value of the rotator angle, i.e., 90°.

Table 3.1: VIMOS Calibration Plan: IMG Mode

Calibration	Number	Frequency	When?	Products	Accuracy	Comment
Bias	5	Daily	Day time	Master Bias	RON	
Darks	3	Monthly	Day time	Dark current		
Sky Flats	5	3-7 days	Twilight time	Master Flat	2%	*U'BVRIz*
Photom. Std.	4 quadrants	See text	Night time	Zero Point	5%	*U'BVRI*
Photom. Std. high airmass	1 quadrant	Weekly	Night time	Extinction coeff.	10%	*U'BVRI*
Astrometric fields	4	6 months	Night time	Distortion map	1 pixel	*R* filter

3.4.3 IMG mode: calibration plan

Observations of IMG photometric standard stars during the same night as science observations are guaranteed for programs that requires photometric conditions, and performed on a best-effort basis during all clear nights. Table 3.1 indicates the nature, frequency and accuracy of VIMOS calibrations expected to be taken as part of the calibration plan. Only calibration frames required for the reduction of science data are reported. More calibrations will be taken by the operation staff for the purpose of maintaining and monitoring the instrument configuration and performance, e.g. mask to CCD transformations etc. These calibrations are not reported here. Calibration monitoring, including photometric zero points, can be found on the pages of the Quality Control group:

http://www.eso.org/observing/dfo/quality/

3.4.4 IMG mode: pipeline

See http://www.eso.org/qc/pipeline-status.html for the information concerning the latest status of the ESO pipeline.

3.4.5 IMG mode: Exposure Time Calculator

The approximate limiting magnitudes in direct imaging mode can be obtained from the exposure time calculator available on the ESO WEB pages http://www.eso.org/observing/etc/.

3.5 Multi-Object Spectroscopy (MOS)

3.5.1 Pre-imaging

Pre-imaging *must* be used to prepare MOS observations when

- no suitably accurate astrometric catalogue of the targets is available,
- or when curved or tilted slits are desired on specific targets

In addition, if a long total MOS exposure time is expected per pre-image field, then there is not much to be gained from skipping pre-imaging.

Pre-imaging is carried out in service mode (see Sect. 3.4.1).

3.5.2 PILMOS: Pre-imageless MOS observations

As of June 2012 Pre-ImageLess Multi Object Spectroscopy (PILMOS) is being offered as an option to VIMOS users. However, currently there are restrictions for MOS observations in PILMOS mode. Constraints that must be met are detailed in Section 7.2.1. In addition we encourage users to take note of the expected PILMOS performance as described in reference [1] of Chapter 7. The implementation of the PILMOS option for mask preparation utilises tools and procedures that were already in place for pre-image based mask preparation, consequently Section 7.3 describes the procedure with particular emphasis on the new PILMOS specific aspects.

Assuming that the constraints detailed in Section 7.2.1 can be met then PILMOS may be particularly appropriate if:

- There is a lack of suitable stars for cross correlation in the field
- Sources are in any case too faint to be identified on VIMOS pre-images
- Each pre-image field has a relatively low total MOS exposure time associated with it
- astrometry accurate to $\pm 0.2''$ is available
- Wide slits ($\geq 1''$) are to be used

Nevertheless, since PILMOS is a new mode, we do not yet recommend this strategy to inexperienced VIMOS users.

3.5.3 Rotator on sky

Because of the atmospheric dispersion effects (Sect. 3.2), the orientation on sky for MOS and pre-imaging observations is restricted to:

- PA=0° (E-W slits), Hour Angle within $\pm 3h$, -45°$< \delta <$-5°;
- PA=90° (N-S slits), Hour Angle within $\pm 2h$, any observable δ.

These restrictions could be lifted with a waiver but it should be very well justified. Notice that the default value for pre-imaging is set to PA=90°. All service and visitor mode users who have particular constraints for the orientation of their fields should request a waiver.

3.5.4 VIMOS Mask Preparation Software (VMMPS)

The use of VMMPS (Chapter 6) is compulsory for the creation of the so-called ADP (Aperture Definition in Pixels) files which are subsequently loaded into p2pp when preparing Observation Blocks. ADP files will be used in Paranal to manufacture the masks. **ADP files should never be edited by hand.**

Here are some general features of VMMPS, for a quick reference guide. Consult the VMMPS web page for instructions on how to retrieve the package and the documentation.

- VMMPS allows to define a mask in two situations:
  - From a contributed catalogue, consisting of list of targets with accurate *relative* astrometry (better than 0.3" rms). Input catalog is a list of RA-DEC coordinates. This catalogue needs to have, with the same *relative* astrometric accuracy, coordinates of bright objects / stars in the field of view. These objects / stars, after detection on the pre-images, will be used to register the target coordinates to the VIMOS coordinate reference frame. Some of these bright stars will be used as reference for acquisition.

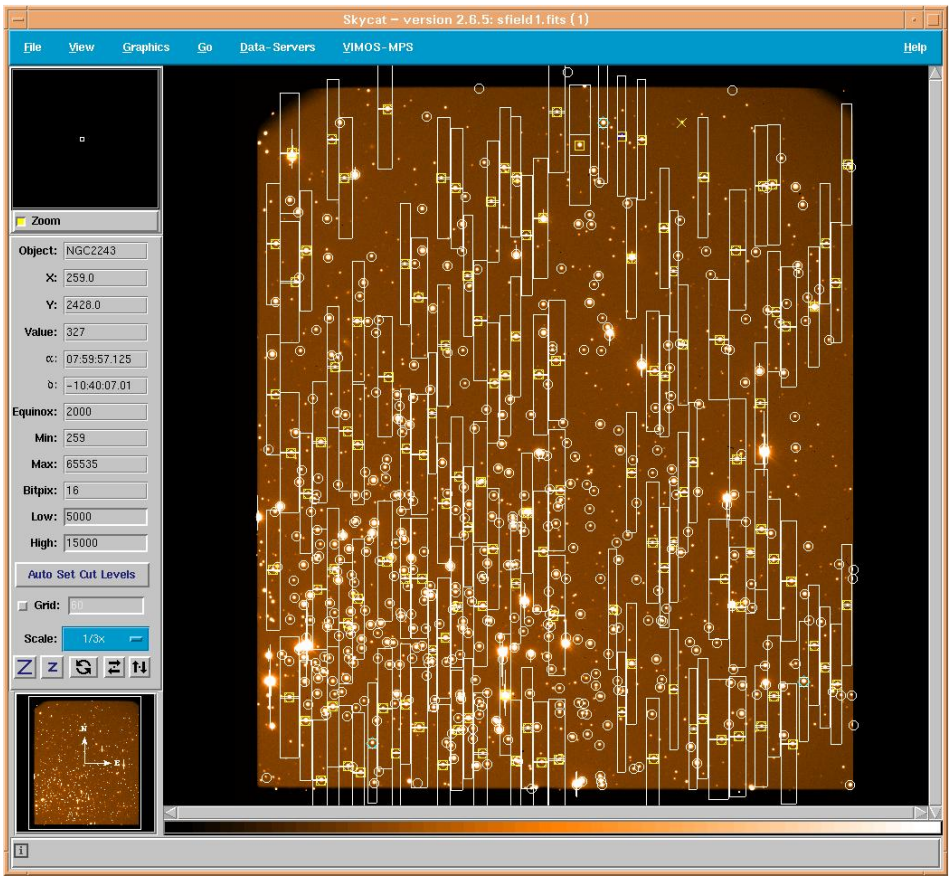


Figure 3.2: VMMPS Graphical User Interface: Example of ADP file superimposed to field of view

  - From a catalog of target positions (in pixel coordinates) **extracted from a VIMOS image**.

- VMMPS maximizes the number of slits that can be assigned to the targets in the input catalogue, in one or more masks, depending on user's choice.

- Upon realization of a first mask definition, VMMPS allows manual interaction to unselect targets, define curved slits, tilted slits, etc. However, note that manual modification of the mask definition should be done only by experienced users and with care.

- VMMPS allows to define some objects as compulsory

- VMMPS requires that some bright stars are defined as reference targets for acquisition purposes.

Figure 3.2 shows the VMMPS Graphical User Interface.

3.5.5 Finding charts

Finding charts for service mode OBs must be prepared with VMMPS. One finding chart for each quadrant must be attached showing all targets with overplotted slits (see Fig. 3.2). **In addition, the first finding chart in P2PP should be a finding chart made with Guidecam showing the guide star and the orientation of the guide probe (see Fig. 5.1).**

3.5.6 Visitors using MOS

Visitors using the MOS mode are requested to prepare Observation Blocks ahead of their scheduled visitor run, and upon completion of their pre-imaging observations (like in service mode). This is to guarantee that visitors will have a sufficient knowledge of the VIMOS Mask Preparation Software (VMMPS, Sect. 3.5.4) prior to their visit at Paranal, and to allow mask manufacturing ahead of time. Limited additional support is guaranteed for mask preparation on the mountain, up to 3 masks per night, to be prepared at least 48 hrs in advance. The instrument has a capacity of 10 masks (per quadrant) loaded simultaneously (one slot is normally occupied by a mask dedicated to observations of spectrophotometric standard stars, and a second one for a pinhole mask used for daily instrument health check). However, some restrictions may apply for technical reasons in the number of masks which can be hosted simultaneously into the cabinets. *Please refer to the Call for Proposals and to the instrument WEB pages for the updated status of the instrument situation.* Note that masks cannot be exchanged at night.

3.5.7 MOS mode: grism+filter setup

In MOS mode only one filter+grism combination per OB is permitted (the only filter exchange allowed is the one between acquisition and science template). Users who want to observe the same targets with different filter+grism combinations are requested to submit separate OBs for different filter+grism combinations and to consider the respective overheads.

Another important thing to keep in mind is that the filter in the acquisition template should overlap in wavelength with the central wavelength of the grism used in the science exposures.

3.5.8 MOS mode: attached night time calibrations

To correct for the effect of instrument flexures it has been mandatory in previous periods to attach nighttime arcs (see Sect. 3.5.9) for all MOS OBs using LR blue and HR blue grisms. During the VIMOS upgrade, one attached arc and three flats have been mandatory for all MOS science observations. The upgrade has been finished and the new HR_blue grisms have been commissioned. We are currently (P93) analysing day- and nighttime calibrations taken since the upgrade for all grisms to analyse whether nighttime calibrations can be skipped in future periods as of P95. Look at the instrument web pages for the latest information on required calibrations.

3.5.9 MOS mode: calibration plan

Observations of spectro-photometric standard stars with the same setting used for science observations are normally performed within a few nights from the science observations.

Table 3.2 indicates the nature, frequency and accuracy of VIMOS calibrations expected to be taken as part of the calibration plan. Only calibration frames required for the reduction of science data are reported. More calibrations will be taken by the operation staff for the purpose of maintaining and monitoring the instrument configuration and performance, e.g. mask to CCD transformations etc. These calibrations are not reported here. Calibration monitoring data can be found on the pages of the Quality Control group:

http://www.eso.org/observing/dfo/quality/

3.5.10 MOS mode: pipeline

See http://www.eso.org/qc/pipeline-status.html for the information concerning the latest status of the ESO pipeline.

Table 3.2: VIMOS Calibration Plan: MOS Mode

Calibration	Number	Frequency	When?	Products	Accuracy[1]	Comment
Bias	5	Daily	Day time	Master Bias	RON	
Darks	3	Monthly	Day time	Dark current		
Screen Flats	≥ 3[2]	Attached to all science OBs		MOS Flat	5 %	All used masks
Screen Arcs	1	Attached to all science OBs		Dispersion coeff.	0.3 pix	All used masks
Specphot. Standard Star	4 quadrants	Weekly	Night time	Response function	10%	All grism+filter setups used

[1] Internal accuracy, not considering instrument flexures (see Sect. 2.7).

[2] During the VIMOS Upgrade Project, starting February 1st 2010, all MOS science settings must be calibrated at night with at least 3 flats and 1 arc.

3.5.11 MOS mode: Exposure Time Calculator

The approximate limiting magnitudes in MOS mode can be obtained from the exposure time calculator available on the ESO WEB pages http://www.eso.org/observing/etc/.

3.6 Integral Field Unit (IFU)

3.6.1 Acquisition accuracy

In IFU mode acquisition is "blind", i.e., limited by the accuracy of the telescope pointing ($\sim 3''$ accuracy). In addition to this the pointing accuracy degrades for targets with declination closer to the South Celestial Pole. At -70° the uncertainty introduced by the current WCS model for the IFU is also $\sim 3''$, increasing rapidly further south. We are working to improve the current model. If you plan to observe very southern targets please be aware that we cannot currently guarantee a very accurate pointing, i.e. the target might fall (partly) out of the IFU FOV.

3.6.2 Dithering/jitter pattern

With the large field of view of the VIMOS-IFU, techniques equivalent to "shift-and-add" classically used in imaging, are a possible mode of operations. Dithering/jitter pattern is a list of differential pointing positions around a central position. Several short images (with exposure times set to have sky background limited exposures) are taken at each position of a dithering pattern, which are combined to reconstruct an image with the total required exposure time. This allows to eliminate the sky contribution, cosmic rays, fringing, cosmetic defects on the detectors, and to produce very accurate flat fielding for correction of pixel to pixel variations. The dithering pattern depends on the mean size of the observed objects: it should be larger than the mean size of the objects for the method to work efficiently.

3.6.3 IFU mode: grism + filter setup

In IFU mode, only one filter+grism combination per OB is permitted. Users who want to observe the same targets with different filter+grism combinations are requested to submit separate OBs for different filter+grism combinations and to consider the respective overheads.

Table 3.3: VIMOS Calibration Plan: IFU Mode

Calibration	Number	Frequency	When?	Products	Accuracy[1]	Comment
Bias	5	Daily	Day time	Master Bias	RON	
Darks	3	Monthly	Day time	Dark current		
Screen Flats	3	Daily	Day time	IFU Flat with HR Orange		Monitoring
Screen Arc	1	Daily	Day time	IFU Arc with HR Orange		Monitoring
Screen Flats	1 to 3[2]	Attached to all science OBs		IFU Flat	5 %	
Screen Arcs	1	Attached to all science OBs		Dispersion coeff.	0.3 pix	
Specphot. Standard Star	4 quadrants	Weekly	Night time	Response function	10%	All grism+filter setups used

[1] Internal accuracy, not considering instrument flexures (see Sect. 2.7).

[2] With grism HR blue, 3 screen flats are always mandatory.

IMPORTANT NOTE The execution time for all IFU attached night time calibrations (screen-flats and arcs) is subtracted from the total allocated time.

3.6.4 IFU mode: attached night time calibrations

To better take into account the effects of instrument flexure the use of attached nighttime calibrations, arcs and flats (see Sect. 3.6.5), is MANDATORY for all IFU OBs. This template will provide 1 or 3 flat-field images (for HR grism: 3 screen-flats are mandatory, for the other cases, the user can choose the number) as well as 1 arc, taken at the same rotator position of the science target. The execution time for these IFU nighttime calibrations is always subtracted from the total allocated time.

3.6.5 IFU mode: calibration plan

Observations of spectro-photometric standard stars with the same setting used for science observations are normally performed within a few nights from the science observations. Table 3.3 indicates the nature, frequency and accuracy of VIMOS calibrations expected to be taken as part of the calibration plan. Only calibration frames required for the reduction of science data are reported. More calibrations will be taken by the operation staff for the purpose of maintaining and monitoring the instrument configuration and performance, e.g. mask to CCD transformations etc. These calibrations are not reported here. Calibration monitoring data can be found on the pages of the Quality Control group:

http://www.eso.org/observing/dfo/quality/

3.6.6 IFU mode: pipeline

See http://www.eso.org/qc/pipeline-status.html for the information concerning the latest status of the ESO pipeline.

3.6.7 IFU mode: Exposure Time Calculator

The approximate limiting magnitudes in IFU mode can be obtained from the exposure time calculator available on the ESO WEB pages http://www.eso.org/observing/etc/.

3.7 VIMOS overheads and OB duration

The current overall efficiency of VIMOS is around 55%. The actual efficiency depends strongly on which instrumental mode is used, and on which observational mode (service vs visitor). The way in which some functions are operated may change at any time. Consequently, we cannot give here an estimate of the overheads that is reliable on the long term. The user is referred to the current Call for Proposals and to the VIMOS web pages for the most updated estimate of the overheads:
http://www.eso.org/sci/facilities/paranal/instruments/vimos/overview.html

It is important during Phase I to be very explicit in the ESO proposal section *Justification of requested observing time and observing conditions* specifying the ETC input parameters used calculating the total on-target time. Then to use a realistic split of that time into OBs of appropriate duration. It is possible to use the the Phase 2 Preparation Tool (P2PP) tutorial account for simulation of example OBs (see P2PP User Manual or VIMOS Phase 2 web pages).

Waiver requests for Service Mode OB duration longer than 1h will be rejected unless a sound scientific argument for longer OBs is presented. In addition, the need for OBs longer than 1h must be explicitly present (and justified) also in Phase I proposal. Sometimes waivers for OB durations of up to 1.5h could be granted if the following conditions are met: (1) it was announced in the Phase I proposal that the waiver was going to be requested; (2) overheads were estimated during Phase I with both 1h and 1.5h OBs and the same on-target total integration time; (3) the seeing constraint is not better than $1.2''$; (4) the target does not come too close to the zenith at Paranal; (5) there is no scheduling conflict with other programmes at similar RA; and (6) the user accepts that the observatory guarantees only the first 1h of execution time to be executed within constraints.

Chapter 4

User Guide to the VIMOS Templates

4.1 Introduction

This section describes the VIMOS templates. Templates are to be used during phase II for service and visitor programmes. Templates are high-level subroutines, writen in TcL to carry out observation subtasks, such as preset telescope or take an image. Each template has an associated *signature file* which defines the data type, value ranges, and information label for each argument to the template (e.g. filter to use, integration time, dither pattern, etc). The observer then use P2PP to assign values to the different arguments.

Templates are grouped together to build an Observation Block (OB), which typically consists of one acquisition template and one or more observing or calibration templates. At the telescope, OBs are passed to the instrument and executed according to the user defined parameter values.

Unless specified otherwise, the information provided in this part applies to both service and visitor modes.

4.2 Template names

VIMOS templates are divided in groups according to the instrument mode and to the observations to be performed. This is reflected in the name of the various templates.

The template naming scheme is the following:

VIMOS_<*mode*>_<*type*>_<*description* >.tsf

where

mode	is the mode of the instrument (either : *img, mos, ifu*)
type	is the type of the template (either: *acq, obs* or *cal*)
description	is a string identifying the purpose of the template (*Offset* for an observation, *Preset* for a preset, *NightCal* for attached night calibrations, etc.)

4.3 Things to know - Reminder

- See Sect. 2.2.1 for a description of the orientation on sky of VIMOS.
- The default orientation on sky for MOS and pre-imaging templates is 90° (see Sect. 3.2). Any departure from this value should be requested with a waiver.
- Offset convention. The templates make extensive use of telescope offsets, which are entered manually as lists. The convention is that offsets are relative to the previous position, and that the first exposure is

executed after the first offset is applied. Thus, if the first exposure is desired at the position of the preset then the first offset should be (0,0). In some templates, the offsets can be defined in detector coordinates (e.g. X, Y), or in RA / DEC. All offsets are to be defined in arcseconds. The offsets refer to the target, so that the target is offset by the requested amount by moving the telescope in the direction opposite to the offset values[1]. Examples are provided further down in the description of the templates.

- Only some combinations of filters and grisms are allowed. See Sect. 2.3 and Table 2.5.

4.4 List of templates

Table 4.4 lists the VIMOS templates.

The description of the templates given in the following pages consist in a table giving all the parameters (keywords) of each template, whether hidden or visible, their range of values, and the label used in P2PP. The hidden parameters have default values which cannot be changed by the users in P2PP. After each table a description of some of the important parameters follow using the P2PP label as heading.

[1] In other words if the preset coordinates are RA_0, DEC_0, then the first pointing of the telescope will center the field at R_1=RA_0−offsetRA_1, DEC_1=DEC_0−offsetDEC_1, (where offsetRA/DEC_1 are the first couple of offset keyword values) and after N offsets the telescope will be pointing to RA_N=RA_N-1−offsetRA_N, DEC_N=DEC_N-1−offsetDEC_N

√	What needs to be done	Name of template	Prefix of image name	TECH	TYPE	CATG
			ACQUISITIONS			
√	Acquisition for imaging sky flat	VIMOS_img_acq_FlatSky	- no images created -			
√	Acquisition for imaging science obs	VIMOS_img_acq_Preset	- no images created -			
√	Acquisition for imaging standard obs	VIMOS_img_acq_Preset	- no images created -			
√	Acquisition for ifu twilight flat	None (at zenith)	- no images created -			
√	Acquisition for ifu science observation	VIMOS_ifu_acq_Preset	- no images created -			
√	Acquisition for ifu specphot standard	VIMOS_ifu_acq_Preset	- no images created -			
√	Acquisition for mos science observation	VIMOS_mos_acq_Mask	VIMOS_MOS_SLIT	IMAGE	SLIT,OBJECT	ACQUISITION
√	Acquisition for mos standard observation without specifying the mask	VIMOS_mos_acq_Standard	VIMOS_MOS_SLIT	IMAGE	SLIT,OBJECT	ACQUISITION
	Acquisition for mos standard observation specifying the mask	VIMOS_mos_acq_Specphot	VIMOS_MOS_SLIT	IMAGE	SLIT,OBJECT	ACQUISITION
			SCIENCE OBSERVATIONS			
√	Observation in IMG mode	VIMOS_img_obs_Offset	VIMOS_IMG_OBS	IMAGE	OBJECT	SCIENCE
√	Observation in IMG mode: pre-imaging	VIMOS_img_obs_Offset	VIMOS_IMG_OBS	IMAGE,PRE	OBJECT	SCIENCE
√	Observation in IFU mode	VIMOS_ifu_obs_Offset	VIMOS_IFU_OBS	IFU	OBJECT	SCIENCE
√	Observation in MOS mode	VIMOS_mos_obs_Offset	VIMOS_MOS_OBS	MOS	OBJECT	SCIENCE
			DAYTIME CALIBRATION OBSERVATIONS			
	Bias frame in IMG mode	VIMOS_img_cal_Dark	VIMOS_IMG_BIAS	IMAGE	BIAS	CALIB
	Dark frame in IMG mode	VIMOS_img_cal_Dark	VIMOS_IMG_DARK	IMAGE	DARK	CALIB
	Bias frame in IFU or MOS mode	VIMOS_spec_cal_Dark	VIMOS_SPEC_BIAS	IMAGE	BIAS	CALIB
	Dark frame in IFU or MOS mode	VIMOS_spec_cal_Dark	VIMOS_SPEC_DARK	IMAGE	DARK	CALIB
	Imaging screen flats	VIMOS_img_cal_ScreenFlat	VIMOS_IMG_LAMP	IMAGE	FLAT,LAMP	CALIB
	IFU Screen flats (specify exposure time)	VIMOS_ifu_cal_ScreenFlat	VIMOS_IFU_LAMP	IFU	FLAT,LAMP	CALIB
	IFU Screen arcs (specify exposure time)	VIMOS_ifu_cal_Arc	VIMOS_IFU_WAVE	IFU	WAVE,LAMP	CALIB
	IFU Screen flats and arcs (no specification of exposure time)	VIMOS_ifu_cal_DayCalib	- same as Arc and ScreenFlat -	IFU	- same -	CALIB
	MOS Screen flats (specify exposure time)	VIMOS_mos_cal_ScreenFlat	VIMOS_MOS_LAMP	MOS	FLAT,LAMP	CALIB
	MOS Screen arcs (specify exposure time)	VIMOS_mos_cal_Arc	VIMOS_MOS_WAVE	MOS	WAVE,LAMP	CALIB
	MOS Screen arcs (specify exposure time)	VIMOS_mos_cal_DayCalib	- same as Arc and ScreenFlat -	MOS	- same -	CALIB
			NIGHTIME CALIBRATION OBSERVATIONS			
√	Imaging skyflats poiting to empty fields	VIMOS_img_cal_FlatSky	VIMOS_IMG_SKY	IMAGE	FLAT,SKY	CALIB
√	Imaging observations of photometric standards	VIMOS_img_cal_Photom	VIMOS_IMG_STD	IMAGE	STD	CALIB
√	Imaging observations of astrometric standard field	VIMOS_img_cal_Astrom				
√	IFU twilight flat field (telecope at zenith, no tracking)	VIMOS_ifu_cal_TwFlat				
√	Attached flats and arcs in IFU mode (no specification of exposure times)	VIMOS_ifu_cal_NightCalib	- same as DayCalib -	IFU	- same -	CALIB
√	IFU observation of spectro photometric standard star	VIMOS_ifu_cal_Specphot	VIMOS_IFU_STD	IFU	STD	CALIB
√	Attached flats and arcs in MOS mode (no specification of exposure times)	VIMOS_mos_cal_NightCalib	-same as DayCalib -	MOS	- same -	CALIB
√	MOS observation of spectro photometric standard star (no need to specify masks)	VIMOS_mos_cal_Standard	VIMOS_MOS_STD	MOS	STD	CALIB
	MOS observation of spectro photometric standard star (need to specify masks)	VIMOS_mos_cal_Specphot	VIMOS_MOS_STD	MOS	STD	CALIB

√: distributed to users ☐: only available at the telescope

4.5 Acquisition templates

4.5.1 VIMOS_img_acq_Preset

VIMOS_img_acq_Preset.tsf			
To be specified:			
Parameter	Hidden	Range *(Default)*	Label
INS.FILT.NAME	no	U B V R I z Free *(NODEFAULT)*	Filter
TEL.AG.GUIDESTAR	no	SETUPFILE CATALOGUE *(CATALOGUE)*	Get Guide Star from
TEL.GS1.ALPHA	no	0..240000 *(0)*	Guide Star RA
TEL.GS1.DELTA	no	-900000..900000 *(0)*	Guide Start DEC
TEL.GS1.PPOS	no	POS NEG *(POS)*	Selected probe position (POS NEG)
TEL.ROT.OFFANGLE	no	-180..180" *(90)*	Rotator on sky
TEL.TARG.ADDVELALPHA	yes	-15..15 *(0)*	Additional Velocity RA
TEL.TARG.ADDVELDELTA	yes	-15..15 *(0)*	Additional Velocity DEC
TEL.TARG.ALPHA	no	*()*	
TEL.TARG.DELTA	no	*()*	
TEL.TARG.EPOCH	no	-2000..3000 *(2000)*	Epoch
TEL.TARG.EQUINOX	no	-2000..3000 *(2000)*	Equinox
TEL.TARG.OFFSETALPHA	no	-3600000..3600000 *(0.)*	Alpha offset
TEL.TARG.OFFSETDELTA	no	-3600000..3600000 *(0.)*	Delta offset
TEL.TARG.PMA	no	-10..10 *(0)*	Proper Motion Alpha
TEL.TARG.PMD	no	-10..10 *(0)*	Proper Motion Delta
Fixed values:			
Parameter	Hidden	Value	Label
INS.MODE	no	IMG	Instrument Mode
SEQ.PRESET	no	T	Preset Telescope ? (T/F)

This template is used for acquisition of a field in imaging mode, for both imaging and pre-imaging OBs. Figure 4.1 shows the P2PP window with an example of a pre-imaging Observing Block (OB).
The coordinates of the target have to be entered in the *Target* window at the bottom of the P2PP window.
The parameters for this template are the following:

- `Filter`. This filter should be the same as for the subsequent imaging template. The available filters are: **U, B, V, R, I, z**.
- `Rotator on sky`. This parameter defines the orientation of the instrument on sky. **For pre-imaging templates this parameter should be set either to 0° (if declination δ lies in -45°$< \delta <$-5°) or to 90° (for any declination), unless a waiver is requested**. The orientation corresponding to 90° is such that the slits will be oriented N-S for the spectroscopic follow-up.
- `Alpha offset` and `Delta offset`. These are optional additional offsets in alpha and delta added to the coordinates of the object specified in the target panel at the bottom of the main p2pp window. The coordinates at the center of the instrument (i.e. the central point between the four quadrants) are the coordinates specified in the Target Package plus the offsets here specified.
- `Get Guide Star From`. Two options are offered for this parameter:
  - **CATALOGUE**. This is the default option for which the guide star will be searched through a catalog and will be selected at the telescope by the Telescope Operator. If this option is selected the subsequent fields (`Guide Star RA / DEC`) will be ignored.

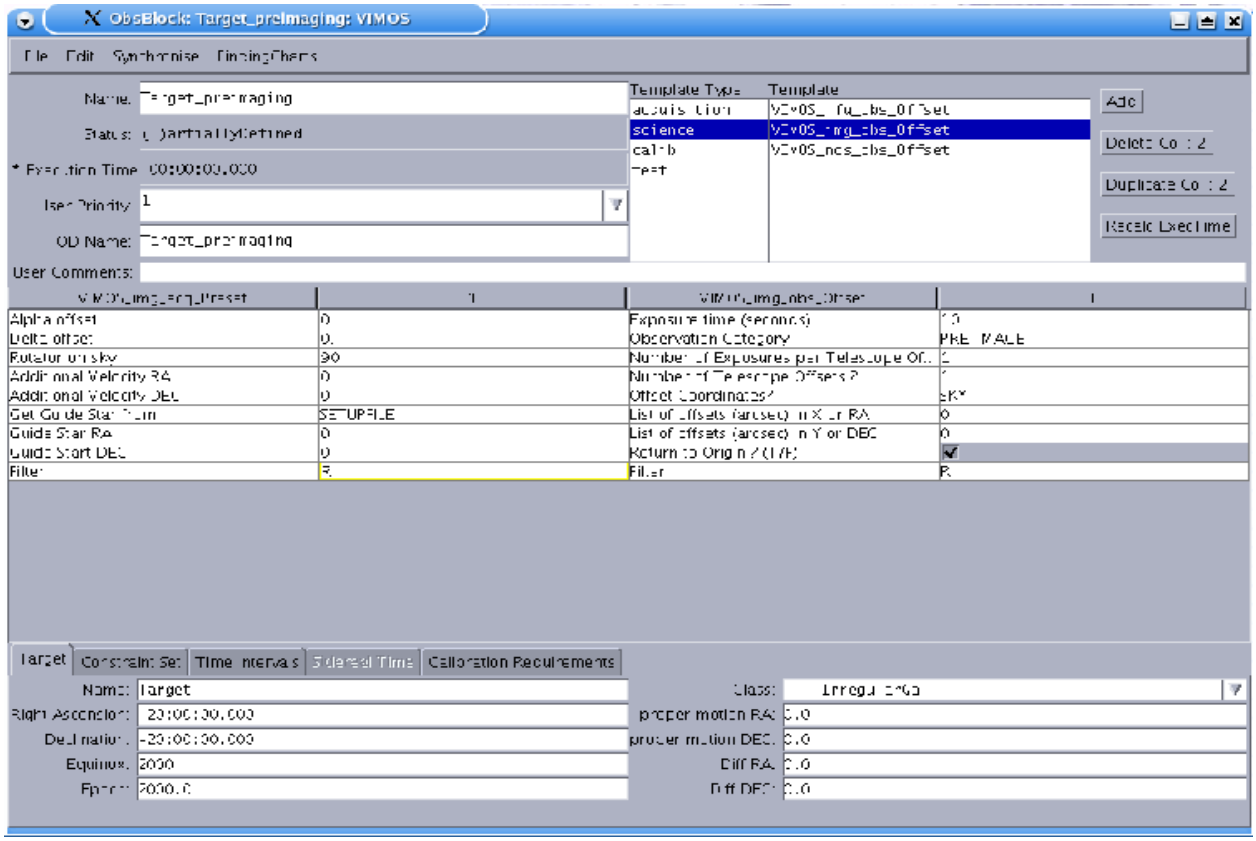


Figure 4.1: P2PP: example of a pre-imaging OB

– **SETUPFILE**. If this option is selected, the guide star that will be used is the one for which the coordinates are defined in the (`Guide Star RA / DEC`) fields. A dedicated tool (Guidecam) is delivered by ESO to help the users to determine the best possible guide star. This option is mandatory for service mode imaging and pre-imaging OBs.

- `Guide Star RA` and `Guide Star DEC`. Coordinates of the guide star when the **SETUPFILE** option of the (`Get Guide Star From`) field is selected.
- `Guide Star PPOS`. Position of the Guide Probe when the **SETUPFILE** option of the (`Get Guide Star From`) field is selected.
- Optional additional velocity (moving targets) in alpha and delta (`Additional Velocity RA` and `Additional Velocity DEC`). This velocity should be expressed in arcsec/sec. These parameters are mostly intended for imaging or possibly IFU programmes of moving targets. If no additional velocity is needed, these parameters should be left to their default values (0.).

4.5.2 VIMOS_img_acq_FlatSky

VIMOS_img_acq_FlatSky.tsf			
To be specified:			
Parameter	Hidden	Range *(Default)*	Label
INS.FILT.NAME	no	U B V R I z Free *(NODEFAULT)*	Filter
TEL.GS1.PPOS	no	POS NEG *(POS)*	Selected probe position (POS NEG)
TEL.ROT.OFFANGLE	no	-180..180" *(0.)*	Rotator angle
TEL.ROTATIO	no	SKY ABSOLUTE *(SKY)*	Rotator angle mode (SKY ABSOLUTE)
TEL.TARG.ADDVELALPHA	yes	-15..15 *(0)*	Additional Velocity RA
TEL.TARG.ADDVELDELTA	yes	-15..15 *(0)*	Additional Velocity DEC
TEL.TARG.ALPHA	no	*()*	
TEL.TARG.DELTA	no	*()*	
TEL.TARG.EPOCH	no	-2000..3000 *(2000)*	Epoch
TEL.TARG.EQUINOX	no	-2000..3000 *(2000)*	Equinox
TEL.TARG.OFFSETALPHA	no	-3600000..3600000 *(0.)*	Alpha offset
TEL.TARG.OFFSETDELTA	no	-3600000..3600000 *(0.)*	Delta offset
TEL.TARG.PMA	no	-10..10 *(0)*	Proper Motion Alpha
TEL.TARG.PMD	no	-10..10 *(0)*	Proper Motion Delta
Fixed values:			
Parameter	Hidden	Value	Label
DET.READ.MODE	no	Medium	Readout mode
INS.MODE	no	IMG	Instrument Mode
SEQ.PRESET	no	T	Preset Telescope ? (T/F)

This template is used to preset telescope to acquire an empty field to obtain twilight flat field exposures. It differ from the normal imaging acquisition in its handling of guiding and active optics which are impossible during twilight. **Only offered in visitor mode.**

The coordinates of the empty field have to be entered in the *Target* window at the bottom of the P2PP window.

- `Filter`. The available filters are: **U, B, V, R, I, z**.
- `Rotator angle`. The rotator angle at which the frames will be obtained. For normal use this is the angle on the sky.
- `Rotator angle mode`. Whether the rotator angle refers to angles on sky or to absolute adapter rotator value. These last option is for tests only and should not be used by visitors.

4.5.3 VIMOS_mos_acq_Mask

VIMOS_mos_acq_Mask.tsf			
To be specified:			
Parameter	Hidden	Range *(Default)*	Label
DET.WIN1.UIT1	no	1..100000 *(NODEFAULT)*	Exposure time (seconds)
INS.ADM1	yes		ADM File 1
INS.ADM2	yes		ADM File 2
INS.ADM3	yes		ADM File 3
INS.ADM4	yes		ADM File 4
INS.ADP1	no		ADP File 1
INS.ADP2	no		ADP File 2
INS.ADP3	no		ADP File 3
INS.ADP4	no		ADP File 4
INS.FILT.NAME	no	U B V R I z OS-blue OS-red GG475 GG435 Free *(NODEFAULT)*	Filter
INS.MASK1.ID	yes	100000..499999 -99 *(-99)*	Mask ID
INS.MASK1.NO	yes	0..15 -99 *(-99)*	Cabinet Slot No
INS.MASK2.ID	yes	100000..499999 -99 *(-99)*	Mask ID
INS.MASK2.NO	yes	0..15 -99 *(-99)*	Cabinet Slot No
INS.MASK3.ID	yes	100000..499999 -99 *(-99)*	Mask ID
INS.MASK3.NO	yes	0..15 -99 *(-99)*	Cabinet Slot No
INS.MASK4.ID	yes	100000..499999 -99 *(-99)*	Mask ID
INS.MASK4.NO	yes	0..15 -99 *(-99)*	Cabinet Slot No
TEL.TARG.ADDVELALPHA	yes	-15..15 *(0)*	Additional Velocity RA
TEL.TARG.ADDVELDELTA	yes	-15..15 *(0)*	Additional Velocity DEC
TEL.TARG.ALPHA	no	*()*	
TEL.TARG.DELTA	no	*()*	
TEL.TARG.EPOCH	no	-2000..3000 *(2000)*	Epoch
TEL.TARG.EQUINOX	no	-2000..3000 *(2000)*	Equinox
TEL.TARG.PMA	no	-10..10 *(0)*	Proper Motion Alpha
TEL.TARG.PMD	no	-10..10 *(0)*	Proper Motion Delta
Fixed values:			
Parameter	Hidden	Value	Label
DET.READ.MODE	no	Medium	Readout mode
DET.WIN1.BINX	no	1	X binning factor
DET.WIN1.BINY	no	1	Y binning factor
INS.MODE	no	MOS	Instrument Mode
SEQ.PRESET	no	T	Preset Telescope ? (T/F)

This template is used for the acquisition of a field to be observed in MOS mode. Note that the acquisition image covers only the central 2048×2400 pixels of each of the 4 CCDs, whereas the spectroscopic images use the full CCD size (2048×4096 pixels).

Preparing a MOS acquisition template requires that masks have been prepared with VMMPS. The output of VMMPS are 'Aperture Definition Files in Pixels' (ADP files). Information concerning the target (coordinates and equinox) are taken from the ADP files and are automatically loaded in the P2PP target package when including the first ADP file in the template.

Figure 4.2 shows the P2PP window with an example of a MOS Acquisition.

The parameters specific to this template are:

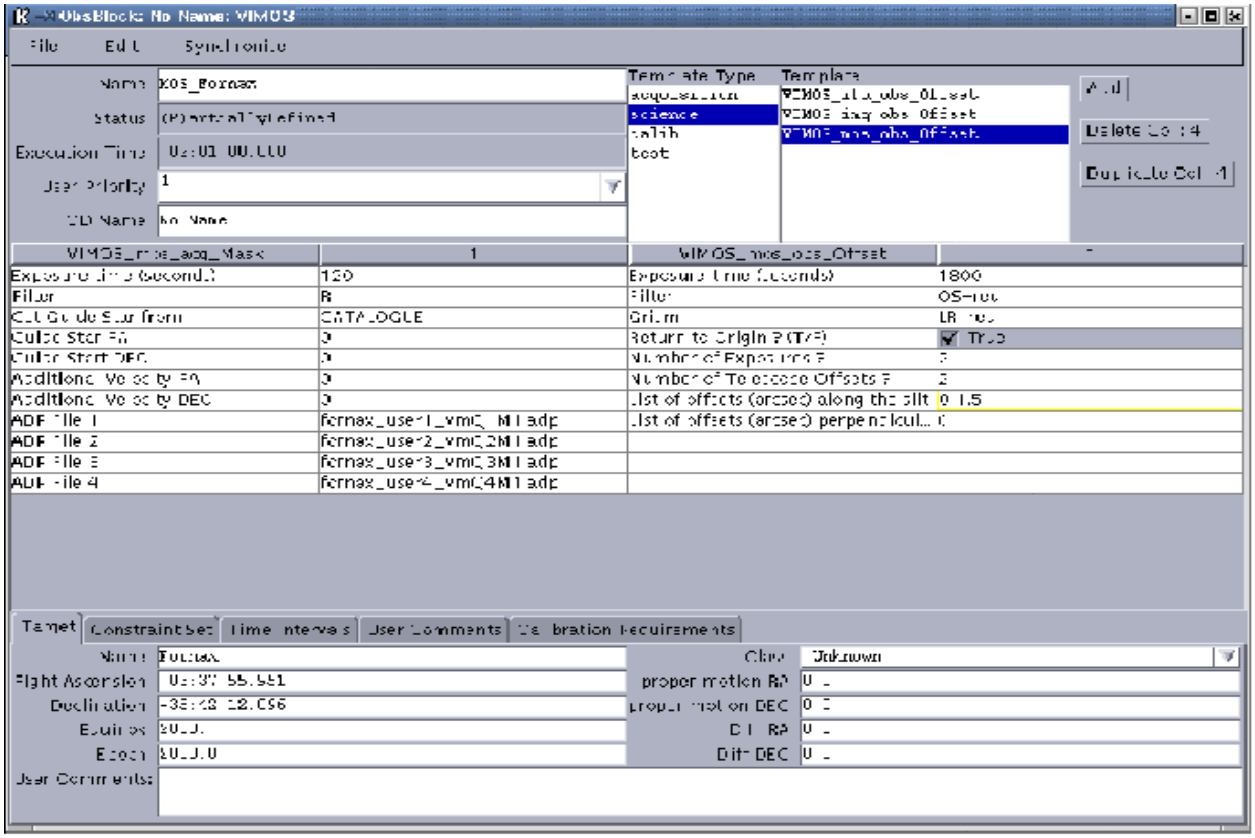


Figure 4.2: P2PP: Example of a MOS OB

- `Exposure time in (seconds)`. This is the integration time for the acquisition image that will be taken through the mask to check the position of the reference stars and of the science target. A typical value is 60s, depending on the brightness of the reference stars defined with VMMPS.

- `Filter`. This filter is the one to be used for the acquisition image. **It is highly recommended to choose the same filter as the one used for the pre-imaging: R.**[2]

- Optional additional velocity (moving targets) in alpha and delta (`Additional Velocity RA` and `Additional Velocity DEC`). This velocity should be expressed in arcsec/sec. These parameters are mostly intended for imaging and possibly IFU programmes of moving targets and a priori unlikely to be of much use in MOS mode. If no additional velocity is needed, these parameters should be left to their default values.

- `ADP files 1` to `ADP file 4`. These 4 parameters are the names of the ADP files produced by VMMPS. The files 1 to 4 correspond to the 4 quadrants of the instrument and should be set in the right order. When selecting an ADP file entry in P2PP, a browser window opens up allowing to locate the file on the local disk. This window is presented in Figure 4.3.

[2]The available filters are: **U, B, V, R, I, z, OS-blue, OS-red, GG435, GG475** and no filter, **Free**.

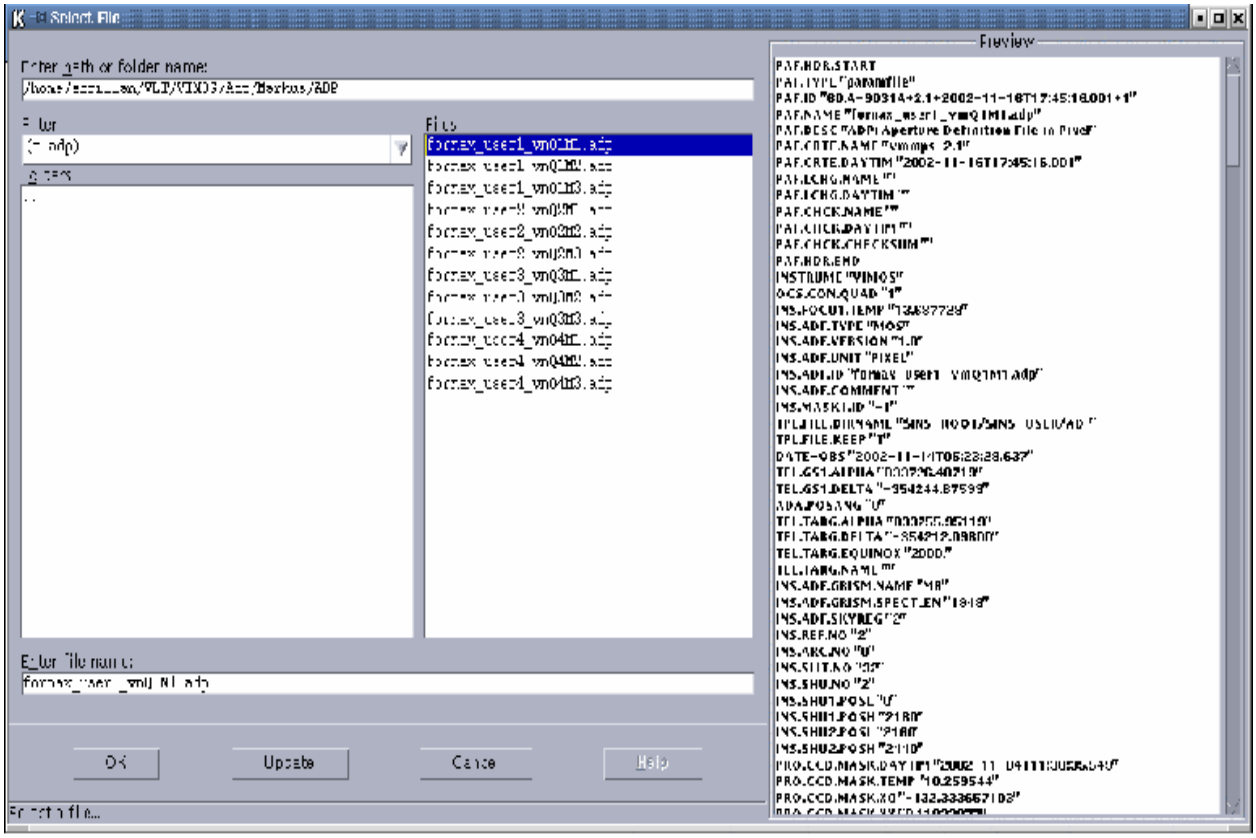


Figure 4.3: P2PP: VIMOS ADP browser window.

4.5.4 VIMOS_mos_acq_Standard

VIMOS_mos_acq_Standard.tsf			
To be specified:			
Parameter	Hidden	Range *(Default)*	Label
DET.WIN1.UIT1	no	1..100000 *(NODEFAULT)*	Exposure time (seconds)
INS.ADM1	yes		ADM File 1
INS.ADM2	yes		ADM File 2
INS.ADM3	yes		ADM File 3
INS.ADM4	yes		ADM File 4
INS.ADP1	yes		ADP File 1
INS.ADP2	yes		ADP File 2
INS.ADP3	yes		ADP File 3
INS.ADP4	yes		ADP File 4
INS.FILT.NAME	no	U B V R I z OS-blue OS-red GG475 GG435 Free *(NODEFAULT)*	Filter
INS.MASK1.ID	yes	100000..499999 -99 *(-99)*	Mask ID
INS.MASK1.NO	yes	0..15 -99 *(-99)*	Cabinet Slot No
INS.MASK2.ID	yes	100000..499999 -99 *(-99)*	Mask ID
INS.MASK2.NO	yes	0..15 -99 *(-99)*	Cabinet Slot No
INS.MASK3.ID	yes	100000..499999 -99 *(-99)*	Mask ID
INS.MASK3.NO	yes	0..15 -99 *(-99)*	Cabinet Slot No
INS.MASK4.ID	yes	100000..499999 -99 *(-99)*	Mask ID
INS.MASK4.NO	yes	0..15 -99 *(-99)*	Cabinet Slot No
TEL.TARG.ADDVELALPHA	yes	-15..15 *(0)*	Additional Velocity RA
TEL.TARG.ADDVELDELTA	yes	-15..15 *(0)*	Additional Velocity DEC
TEL.TARG.ALPHA	no	*()*	
TEL.TARG.DELTA	no	*()*	
TEL.TARG.EPOCH	no	-2000..3000 *(2000)*	Epoch
TEL.TARG.EQUINOX	no	-2000..3000 *(2000)*	Equinox
TEL.TARG.PMA	no	-10..10 *(0)*	Proper Motion Alpha
TEL.TARG.PMD	no	-10..10 *(0)*	Proper Motion Delta
Fixed values:			
Parameter	Hidden	Value	Label
DET.READ.MODE	no	Medium	Readout mode
DET.WIN1.BINX	no	1	X binning factor
DET.WIN1.BINY	no	1	Y binning factor
INS.MODE	no	MOS	Instrument Mode
SEQ.HEADER	no	F	Header type
SEQ.PRESET	no	T	Preset Telescope ? (T/F)
TEL.AG.GUIDESTAR	no	CATALOGUE	Get Guide Star from
TEL.ROT.OFFANGLE	no	90	Rotator on sky

This template is used for the acquisition in mode MOS, using the specially designed set of calibrations masks provided by Paranal. This set of masks contains a series of slits of different width that can be used for all calibrations that requires the use of a standard star (i.e spectrophotometric, radial velocity or metallicity standard). Since the template is using a pre-defined set of masks no ADP need to be provided by the user. No reference stars are used for the acquisition.

IMPORTANT: the coordinates of the standard star should be accurate to better than $1''$, including proper motion effects; the star has to be visible within a $10'' \times 10''$ acquisition box;

Note: the coordinates of the standard star should be set by the user in the target sub-window in P2PP;

Note: the rotator angle is fixed for this template at 90° corresponding to the set of slits in the masks oriented along the N-S direction.

The parameters of the template are:

- `Exposure time (seconds)`. This is the integration time for the acquisition image that will be taken through the mask to check its positioning.
- `Filter`. This filter is the one to be used for the acquisition image. **It is recommended to choose the right combination filter/exptime to avoid the saturation of the star in the acquisition image**

  The available filters are: **U, B, V, R, I, z, OS-blue, OS-red, GG435, GG475** and no filter.
- Optional additional velocity (moving targets) in alpha and delta (`Additional Velocity RA` and `Additional Velocity DEC`). This velocity should be expressed in arcsec/sec. These parameters are mostly intended for imaging and possibly IFU programs of moving targets and a priori unlikely to be of much use in MOS mode. If no additional velocity is needed, these parameters should be left to their default values.

4.5.5 VIMOS_ifu_acq_Preset

VIMOS_ifu_acq_Preset.tsf			
To be specified:			
Parameter	Hidden	Range *(Default)*	Label
INS.FILT.NAME	no	U B V R I z OS-blue OS-red GG475 GG435 Free *(NODEFAULT)*	Filter
INS.GRIS.NAME	no	LR_blue LR_red HR_blue HR_red HR_orange MR *(NODEFAULT)*	Grism
INS.IFUE.NAME	no	0.33 0.67 *(0.67)*	IFU Magnification (arcsec/fiber)
INS.IFUS.MODE	no	T F *(F)*	IFU Shutter
TEL.AG.GUIDESTAR	no	SETUPFILE CATALOGUE *(CATALOGUE)*	Get Guide Star from
TEL.GS1.ALPHA	no	0..240000 *(0)*	Guide Star RA
TEL.GS1.DELTA	no	-900000..900000 *(0)*	Guide Start DEC
TEL.ROT.OFFANGLE	no	-180..180" *(0.)*	Rotator on sky
TEL.TARG.ADDVELALPHA	yes	-15..15 *(0)*	Additional Velocity RA
TEL.TARG.ADDVELDELTA	yes	-15..15 *(0)*	Additional Velocity DEC
TEL.TARG.ALPHA	no	*()*	
TEL.TARG.DELTA	no	*()*	
TEL.TARG.EPOCH	no	-2000..3000 *(2000)*	Epoch
TEL.TARG.EQUINOX	no	-2000..3000 *(2000)*	Equinox
TEL.TARG.OFFSETALPHA	no	-3600000..3600000 *(0.)*	Alpha offset
TEL.TARG.OFFSETDELTA	no	-3600000..3600000 *(0.)*	Delta offset
TEL.TARG.PMA	no	-10..10 *(0)*	Proper Motion Alpha
TEL.TARG.PMD	no	-10..10 *(0)*	Proper Motion Delta
Fixed values:			
Parameter	Hidden	Value	Label
INS.MODE	no	IFU	Instrument Mode
SEQ.PRESET	no	T	Preset Telescope ? (T/F)

This template is for the acquisition of a field to be observed with the Integral Field Unit. Unlike the MOS acquisition template, the IFU acquisition template requires to define the filter / grism combination that will be used in the following observation template. This is to optimize the setup of the instrument at acquisition time.

The coordinates of the field at the center of the IFU need to be entered in the Target Package at the bottom left of the main P2PP window.

The parameters for this template are:

- `Filter`. This should be the same filter as the one used in the first observation template following this acquisition template. **In order to produce a valid OB, the filter in the first observation template following this acquisition template should be the same**. The available filters are: **U, B, V, R, I, z, OS-blue, OS-red, GG435, GG475** and no filter.

  Only standard filter / grism combinations are allowed, as indicated in Table 2.5. Other combinations should be requested with a waiver.

- `Grism`. This is the grism that is used in the first observation template following this acquisition template. **In order to produce a valid OB, the grism in the first observation template following this acquisition template should be the same**.

  The available grisms are: **LR_blue, LR_red, MR, HR_blue, HR_orange, HR_red**.

- `IFU Magnification`. This parameter defines the sampling, and correspondingly the field of view of the IFU. The 2 available samplings are 0.67 arcsec/fiber and 0.33 arcsec/fiber. **To produce a valid OB, the magnification should be the same in every template of the OB**. Observations requiring different samplings on the same field should resort to several OBs.

- `IFU Shutter`. This parameter is only meaningful when using the **LR** grisms. In **LR** spectroscopy, there are 4 rows of fibers along the dispersion direction, whereas in **MR** and **HR** modes only one 'slit' of fibers is used, hence the variation of field of view between **LR** and **MR** and **HR** modes. In case the object of interest is of limited size in **LR** mode, and if only the central $1/4 \times 1/4$ of the field of view is needed, it is possible with the `IFU Shutter` option to mask the outer part of the IFU (always masked in **MR** and **HR** modes). This allows to avoid second order overlap due to sky and / or background objects between the 4 adjacent slits along the dispersion direction. **True** means that the shutter is in place and masks the external part of the IFU, **False** (the default value) means that the mask is not in place and the full IFU field of view is available. **To produce a valid OB, the mask shutter option should be the same in every template of the OB**. This parameter is ignored when **MR** or **HR** grisms are used.

- `Rotator on Sky`. This parameter defines the orientation of the instrument on sky. The IFU has a square geometry with the sides oriented N-S and E-W. With a rotator angle of zero the orientation of the IFU on the sky is with the North up and the East to the left. The increasing (positive) position angle on the sky (east of north) corresponds to the positive rotator angle. Therefore the value of this keyword should be equal to the desired position angle (PA) on the sky (see Fig. 2.5).

- Optional additional offsets in alpha and delta (`Alpha Offset` and `Delta offset`) with respect to the coordinates of the object. The coordinates at the center of the IFU are the coordinates specified in the Target Package plus the offsets here specified. This can be useful e.g. to define small offsets between the initial pointings on the same field over several OBs.

- `Get Guide Star From`. Two options are offered for this parameter:

  - **CATALOGUE**. This is the default option for which the guide star will be searched through a catalog and will be selected at the telescope by the Telescope Operator. If this option is selected the subsequent fields (`Guide Star RA / DEC`) will be ignored. Given that the quasi-total Nasmyth field of view is accessible to choose a guide star in IFU mode, the users can safely use this option.
  - **SETUPFILE**. If this option is selected, the guide star that will be used is the one for which the coordinates are defined in the (`Guide Star RA / DEC`) fields. As indicated above, it is unlikely that this option is required in IFU mode. Note that Guidecam tool is not intended to be used to select guide stars for the IFU mode, but only for the IMG and MOS mode of VIMOS.

- `Guide Star RA` and `Guide Star DEC`. Coordinates of the guide star when the **SETUPFILE** option of the `Get Guide Star From` field is selected.

- Optional additional velocity (moving targets) in alpha and delta (`Additional Velocity RA` and `Additional Velocity DEC`) This velocity should be expressed in arcsec/sec. If no additional velocity is needed, these parameters should be left to their default values.

4.6 Science templates

4.6.1 VIMOS_img_obs_Offset

VIMOS_img_obs_Offset.tsf			
To be specified:			
Parameter	Hidden	Range *(Default)*	Label
DET.WIN1.UIT1	no	1..100000 *(NODEFAULT)*	Exposure time (seconds)
INS.FILT.NAME	no	U B V R I z Free *(NODEFAULT)*	Filter
SEQ.CATG	no	PRE-IMAGE SCIENCE TECHNICAL *(SCIENCE)*	Observation Category
SEQ.NEXPO	no	1..1000000 *(1)*	Number of Exposures per Telescope Offset ?
SEQ.NOFF	no	1..1000000 *(NODEFAULT)*	Number of Telescope Offsets ?
SEQ.OFFSET.COORDS	no	SKY DETECTOR *(NODEFAULT)*	Offset Coordinates?
SEQ.OFFSET1.LIST	no	*(0)*	List of offsets (arcsec) in X or RA
SEQ.OFFSET2.LIST	no	*(0)*	List of offsets (arcsec) in Y or DEC
SEQ.RETURN	no	F T *(T)*	Return to Origin ? (T/F)
Fixed values:			
Parameter	Hidden	Value	Label
DET.READ.MODE	no	Medium	Readout mode
DET.WIN1.BINX	no	1	X binning factor
DET.WIN1.BINY	no	1	Y binning factor
INS.MODE	no	IMG	Instrument Mode
SEQ.HEADER	no	F	Header type

This template is used for Imaging mode observation both for **Science** and **Pre-imaging**. The parameters of this template are the following:

- `Exposure time in (seconds)`. This is the integration time in seconds per exposure.
- `Filter`. The available filters are: **U, B, V, R, I, z**. **In order to produce a valid OB the filter in the first observation template following the acquisition template should be the same as the one selected in the acquisition template. For pre-imaging the use of R filter is mandatory**.
- `Return to Origin? (T/F)`. This parameter defines whether or not, after a dithered set of observations, the telescope will return to the position at the beginning of template. As an example, this parameter should be set to 'T' when the aim of the OB is to execute multi-color imaging observations with the same pattern of offsets on the same field using different templates. This parameter is in general to be left to its default value (T) in service mode. **If another value is desired in service mode a waiver should be requested**.
- `Number of Telescope Offsets?`. This parameter defines the number of telescope offsets during the template. The number of exposures taken at each telescope position is determined by the next parameter (`Number of exposures per telescope offset ?`). The pattern of offsets is defined in the parameters (`List of offsets (arcsec) in X or RA`) and (`List of offsets (arcsec) in Y or DEC`). Offsets are defined relative to the previous position.
- `Number of exposures per telescope offset?`. This parameter defines how many exposures are taken at each offset position.

- `Offset coordinates?`. This parameter defines the coordinate system used to define telescope offsets. If the **SKY** option is selected, telescope offsets are in RA and DEC, if **DETECTOR** is selected, telescope offsets are in X and Y on the detector. In both cases the offsets are given in **arcsec**.

- `List of offsets (arcsec) in X or RA` and `List of offsets (arcsec) in Y or DEC`. List of offsets between exposures. Offsets are defined relative to the previous position. The offsets are defined in RA/DEC or X/Y on detector depending on which option is selected for the (`Offset coordinates`) field. If the first image is to be taken at the preset coordinates, the first set of offsets should be 0,0. If there are less offset values than the defined number of offset positions, the template will return at the beginning of the list of offsets and apply them again.

  IMPORTANT: We stress that, in contrast with other ESO instruments, the offsets defined by the user in P2PP refer to the apparent movement of the target on the detector independently of the choice of `Offset coordinates` **(SKY or DETECTOR), and not to the offsets applied to the telecope**:

  For example, if 5 telescopes offsets are defined (number of telescope offsets?) together with the following series of offsets (apparent movement of the target on the detector):

RA or X	0	-10	-5
DEC or Y	2	7	

  the offsets applied to the telescope will be:

RA or X	0	10	5	0	10
DEC or Y	-2	-7	-2	-7	-2

  If SKY option for coordinates is selected, then after the preset the first offset will be applied to place the target 2 arcsec North with respect to its previous position on the detector by moving the telescope 2 arcsec to the South (0 offset in RA). At this position the first exposure will be taken. After that the target will be moved further 10 arcsec West and 7 arcsec North with respect to the position of the previous exposure, etc. until the number of exposures is reached.

  If DETECTOR option for coordinates is selected, then the directions of the offsets on sky depends on the actual rotator angle. If we assume that the orientation is such that the positive x-axis points to the East, and positive y-axis points to the North (see Figure 2.3) then: if the target falls at pixel $x = 0$, $y = 0$, after the telescope preset then the first exposure will be taken with the target at pixels $x = 0$, $y = 10$ (offset is $2''$, which is approximately 10 pixels). In other words, the telescope was moved 10 pixels in the directions of the negative y axis of the detector. Then the target will move to the pixel position $x = -50$ and $y = 45$ on the detector, which corresponds in this case (PA=0) to a movement of the telescope of $10''$ East and $7''$ South with respect to the previous position, etc., until the number of exposures is reached.

  If the rotator angle is different than zero, for example PA=-45, and the offset defined in P2PP are

RA or X	0	2	0	-2	0	0	-2	0
DEC or Y	0	0	5	0	-5	-5	0	5

  then Figure 4.4 and Figure 4.5 give the performed offsets in the case of DETECTOR and SKY coordinates respectively.

- `Observation Category`. **PRE-IMAGE** is for a pre-imaging program, **SCIENCE** is for a regular science imaging program. Never choose TECHNICAL.

  It is critical that users define PRE-IMAGE for pre-imaging programs. Failure to do so will result in slow processing and delivery (possibly till the end of the period) of the data.

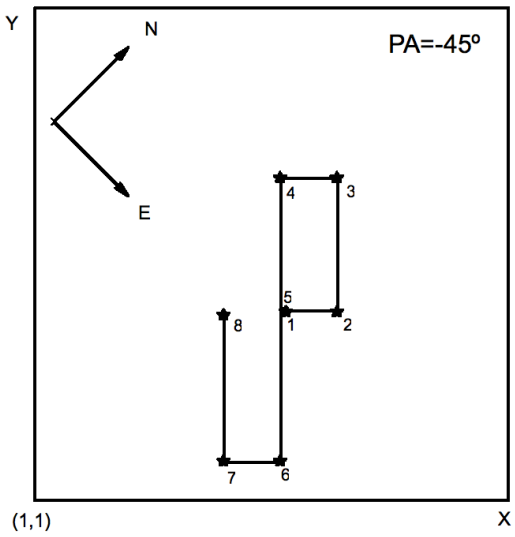


Figure 4.4: Illustration of the VIMOS_img_obs_Offset template. The black dots represent the position of a star, which was originally at the center of the field. In this example the DETECTOR option is selected, and the star (not the telescope) is moved in X and Y according to the list of offsets.

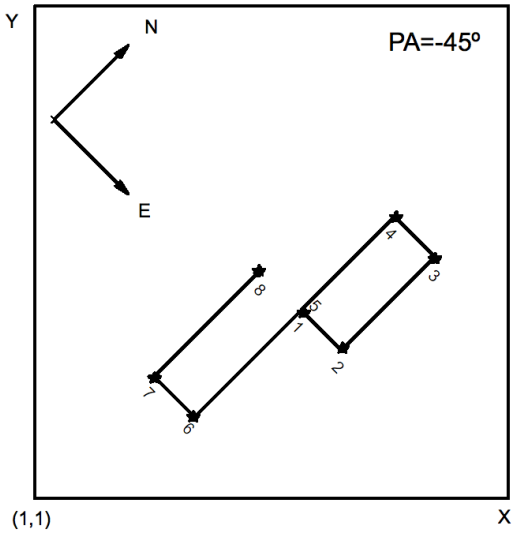


Figure 4.5: Illustration of the VIMOS_img_obs_Offset template. The black dots represent the position of a star, which was originally at the center of the field. In this example, the SKY option is selected, and the telescope is moved in RA and DEC in the opposite direction of the offsets in the list so that the star moves in RA/DEC according to the offset list.

4.6.2 VIMOS_mos_obs_Offset

VIMOS_mos_obs_Offset.tsf			
To be specified:			
Parameter	Hidden	Range *(Default)*	Label
DET.WIN1.UIT1	no	1..100000 *(NODEFAULT)*	Exposure time (seconds)
INS.FILT.NAME	no	U B V R I z OS-blue OS-red GG475 GG435 Free *(NODEFAULT)*	Filter
INS.GRIS.NAME	no	LR_blue LR_red HR_blue HR_red HR_orange MR *(NODEFAULT)*	Grism
SEQ.CATG	no	SCIENCE TECHNICAL *(SCIENCE)*	Observation Category
SEQ.NEXPO	no	1..1000000 *(1)*	Number of Exposures per Telescope Offset ?
SEQ.NOFF	no	1..1000000 *(NODEFAULT)*	Number of Telescope Offsets ?
SEQ.OFFSET1.LIST	no	*(NODEFAULT)*	List of offsets (arcsec) along the slit
SEQ.OFFSET2.LIST	no	*(0)*	List of offsets (arcsec) perpendicular to the slit
SEQ.RETURN	no	F T *(T)*	Return to Origin ? (T/F)
Fixed values:			
Parameter	Hidden	Value	Label
DET.READ.MODE	no	Medium	Readout mode
DET.WIN1.BINX	no	1	X binning factor
DET.WIN1.BINY	no	1	Y binning factor
INS.MODE	no	MOS	Instrument Mode
SEQ.HEADER	no	F	Header type

The parameters of this template are:

- `Exposure time in (seconds)`. This is the integration time in seconds per exposure.
- `Filter`. The available filters are: **U, B, V, R, I, z, OS-blue, OS-red, GG435, GG475** and no filter. The standard grism / filter configurations are given in Table 2.5.

  Only standard filter / grism combinations are allowed, as indicated in Table 2.5. Other combinations should be requested with a waiver.
- `Grism`. The available grisms are: **LR_blue, LR_red, MR, HR_blue, HR_orange, HR_red**.
- `Return to Origin? (T/F)`. This parameter defines whether or not, after a dithered set of observations, the telescope will return at the position at beginning of the template. **This parameter is in general to be left in the default value (T) in service mode. If another value is desired in service mode a waiver should be requested**.
- `Number of Telescope Offsets?`. This parameter defines the number of telescope offsets during the template. The number of exposures taken at each telescope position is determined by the next parameter (`Number of exposures per telescope offset ?`). The pattern of offset is defined in the `List of offsets (arcsec) along the slit` and `List of offsets (arcsec) perpendicular to the slit` parameters.
- `Number of exposures per telescope offset?`. This parameter defines how many exposures are taken at each offset position.

- `List of offsets (arcsec) along the slit` and `List of offsets (arcsec) perpendicular to the slit`. Offsets are defined relative to the previous position. Offsets are defined in DETECTOR coordinates, along or perpendicular to the slits. Usually, only offsets along the slits need to be defined. If the first image is to be taken at the preset coordinates, the first set of offset should be 0,0. If there are less offset values than the required number of offset position, the template will return at the beginning of the list of offsets and apply them again.

  For example, if 3 telescope offsets are defined (`Number of Telescope Offsets?`) together with the following series of offsets (apparent movement of the target on the detector):

`List of offsets (arcsec) along the slit`	-1 2 0
`List of offsets (arcsec) perpendicular to the slit`	0

  the offsets applied to the telescope will be:

`Offsets (arcsec) along the slit`	1	-2	0
`Offsets (arcsec) perpendicular to the slit`	0	0	0

  (i.e., the first exposure is taken at $-1''$ from the pointing position along the slit, then the second exposure is taken $2''$ up along the slit with respect to the previous exposure, and the third exposure is taken at the same position as the second.)

- `Observation Category`. **SCIENCE** is for a regular science MOS program. Never choose TECHNICAL.

4.6.3 VIMOS_ifu_obs_Offset

VIMOS_ifu_obs_Offset.tsf			
To be specified:			
Parameter	Hidden	Range *(Default)*	Label
DET.WIN1.UIT1	no	1..100000 *(NODEFAULT)*	Exposure time (seconds)
INS.FILT.NAME	no	U B V R I z OS-blue OS-red GG475 GG435 Free *(NODEFAULT)*	Filter
INS.GRIS.NAME	no	LR_blue LR_red HR_blue HR_red HR_orange MR *(NODEFAULT)*	Grism
INS.IFUE.NAME	no	0.33 0.67 *(0.67)*	IFU Magnification (arcsec/fiber)
INS.IFUS.MODE	no	T F *(F)*	IFU Shutter
SEQ.CATG	no	SCIENCE TECHNICAL *(SCIENCE)*	Observation Category
SEQ.NEXPO	no	1..1000000 *(1)*	Number of Exposures per Telescope Offset ?
SEQ.NOFF	no	1..1000000 *(NODEFAULT)*	Number of Telescope Offsets ?
SEQ.OFFSET1.LIST	no	*(0)*	List of offsets (arcsec) in RA
SEQ.OFFSET2.LIST	no	*(0)*	List of offsets (arcsec) in DEC
SEQ.RETURN	no	F T *(T)*	Return to Origin ? (T/F)
Fixed values:			
Parameter	Hidden	Value	Label
DET.READ.MODE	no	Medium	Readout mode
DET.WIN1.BINX	no	1	X binning factor
DET.WIN1.BINY	no	1	Y binning factor
INS.MODE	no	IFU	Instrument Mode
SEQ.HEADER	no	F	Header type
SEQ.OFFSET.COORDS	no	SKY	Offset Coordinate?

This template is to be used for observation with the Integral Field Unit. The parameters of this template are:

- `Exposure time in (seconds)`. This is the integration time in seconds per exposure.
- `Filter`. The available filters are: **U, B, V, R, I, z, OS-blue, OS-red, GG435, GG475** and no filter. **Only standard filter / grism combinations are allowed, as indicated in Table 2.5. Other combinations should be requested with a waiver**.
- `Grism`. The available grisms are: **LR_blue, LR_red, MR, HR_blue, HR_orange, HR_red**.

In order to produce a valid OB the filter and the grism in the first observation template following the acquisition template should be the same as the one selected in the acquisition template.

- `IFU Magnification`. This parameter defines the sampling, and correspondingly the field of view of the IFU. The 2 available samplings are 0.67 arcsec/fiber and 0.33 arcsec/fiber.

  To produce a valid OB, the magnification should be the same in every template of the OB.

- `IFU Shutter`. This parameter is only meaningful when using the **LR** grisms. In **LR** spectroscopy, there are 4 rows of fibers along the dispersion direction, whereas in **MR** and **HR** modes only one 'slit' of fibers is used, hence the variation of field of view between **LR** and **MR** and **HR** modes. In case the

object of interest is of limited size in **LR** mode, and if only the central $1/4 \times 1/4$ of the field of view is needed, it is possible with the `IFU Shutter` option to mask the outer part of the IFU (always masked in **MR** and **HR** modes). This allows to avoid second order overlap due to sky and / or background objects between the 4 adjacent slits along the dispersion direction. **True** means that the shutter is in place and masks the external part of the IFU, **False** (the default value) means that the mask is not in place and the full IFU field of view is available. **To produce a valid OB, the mask shutter option should be the same in every template of the OB**. This parameter is ignored when **MR** or **HR** grisms are used.

- `Return to Origin? (T/F)`. This parameter defines whether or not, after a dithered set of observations, the telescope will return to the reference position. This parameter is in general to be left in the default value (T) in service mode. **If another value is desired in service mode a waiver should be requested**.

- `Number of Telescope Offsets?`. This parameter defines the number of telescope offsets during the template. The number of exposures taken at each telescope position is determined by the next parameter (`Number of exposures per telescope offset ?`). The pattern of offset is defined in the `List of offsets (arcsec) CORRECT LABEL` and `List of offsets (arcsec) CORRECT LABEL` parameters.

- `Number of exposures per telescope offset?`. This parameter defines how many exposures are taken for each offset position.

- `List of offsets (arcsec)` List of offsets between exposures. Offsets are defined relative to the previous position. The offsets are defined in RA/DEC. If the first image is to be taken at the preset coordinates, the first set of offsets should be 0,0. If there are less offset values than the defined number of offset positions, the template will return at the beginning of the list of offsets and apply them again.

  For example, if 5 telescope offsets are defined (`Number of Telescope Offsets?`) together with the following series of offsets (apparent movement of the target on the detector in RA/DEC):

RA	0	-10	-5
DEC	0	5	10

  the offsets applied to the telescope will be (see also Sect. 4.6.1):

RA	0	10	5	0	10
DEC	0	-5	-10	0	-5

- `Observation Category`. **SCIENCE** is for a regular science IFU program. Never choose TECHNICAL.

4.7 Calibration Templates

4.7.1 VIMOS_img_cal_FlatSky

VIMOS_img_cal_FlatSky.tsf			
To be specified:			
Parameter	Hidden	Range *(Default)*	Label
INS.FILT.NAME	no	U B V R I z Free *(NODEFAULT)*	Filter
SEQ.EXPLEVEL	no	200..40000 *(10000)*	Exposure Level
SEQ.NEXPO	no	1..1000000 *(1)*	Number of exposure?
SEQ.OFFSET1.LIST	no	*(0)*	List of offsets (arcsec) in X or RA
SEQ.OFFSET2.LIST	no	*(0)*	List of offsets (arcsec) in Y or DEC
TEL.ROT.OFFANGLE	no	-180..180" *(0.)*	Rotator angle
TEL.ROTATIO	no	NONE ABSOLUTE *(NONE)*	Rotator angle mode (SKY ABSOLUTE)
Fixed values:			
Parameter	Hidden	Value	Label
DET.READ.MODE	no	Medium	Readout mode
DET.WIN1.BINX	no	1	X binning factor
DET.WIN1.BINY	no	1	Y binning factor
INS.MODE	no	IMG	Instrument Mode
SEQ.HEADER	no	F	Header type
SEQ.NOFF	no	1	Number of Telescope Offsets ?

This template takes SEQ.NEXPO, dithered, sky flat frames. The user can specify the desired exposure level. **Offered only in visitor mode.**

The parameters of this template are:

- `Exposure Level (ADU)`. This is the desired exposure level which the template will attempt to keep constant.
- `Filter`. The available filters are: **U, B, V, R, I, z**.
- `Number of exposures?`. This parameter defines how many exposures are taken. The telescope should be offseted between exposures.
- `List of offsets`. These parameters are used to specify offsets, in arcsecond, in SKY coordinates. The offsets should be large enough so that halos of bright stars do not affect the data (we attempt to use only empty fields, buth the VIMOS FoV is large so sometime this is not possible. The offsets should be at least 15" in size.
- `Rotator angle`. The rotator angle at which the frames will be obtained. For normal use this is the angle on the sky.
- `Rotator angle mode`. Whether the rotator angle refers to angles on sky or to absolute adapter rotator value. These last option is for tests only and should not be used by visitors.

4.7.2 VIMOS_img_cal_Photom

VIMOS_img_cal_Photom.tsf			
To be specified:			
Parameter	Hidden	Range *(Default)*	Label
DET.WIN1.UIT1	no	1..100000 *(NODEFAULT)*	Exposure time (seconds)
INS.FILT.NAME	no	U B V R I z Free *(NODEFAULT)*	Filter
SEQ.CAL.FLAG	no	1 4 *(1)*	1 or 4 quadrants?
SEQ.NEXPO	no	1..1000000 *(1)*	Number of Exposures per Telescope Offset ?
Fixed values:			
Parameter	Hidden	Value	Label
DET.READ.MODE	no	Medium	Readout mode
DET.WIN1.BINX	no	1	X binning factor
DET.WIN1.BINY	no	1	Y binning factor
INS.MODE	no	IMG	Instrument Mode
SEQ.HEADER	no	F	Header type

This template is for acquisition of photometric data (zero points) in Imaging mode. The acquisition template to use with this template is VIMOS_img_acq_Preset. The coordinates to define in the acquisition template are those of the standard star / field. Offsets from these coordinates to position the star / field in one or the four quadrants of the instrument will be applied automatically by the template.

The parameters of this template are:

- `Exposure time (seconds)`. This is the integration time in seconds per exposure.
- `Filter`. The available filters are: **U, B, V, R, I, z**. **To produce a valid calibration OB the filter in the first observation template following the acquisition template should be the same as the one in the acquisition template**.
- `Number of exposures per telescope offset ?`. This parameter defines how many exposures are taken at each offset position (1 or 4).
- `1 or 4 quadrants`. This parameter allows to define if the standard star image will be taken in 1 or 4 quadrants. If the **1 quadrant** option is selected, the standard star field will be positioned in only one quadrant by applying an appropriate offset from the coordinates of the star / field defined in the target package of the acquisition template.

  If the **4 quadrant** option is selected, the standard star field will be positioned sequentially in the 4 quadrants by applying the appropriate offsets from the coordinates of the star / field defined in the target package of the acquisition template.

  As many exposures as defined in (`Number of exposures per telescope offset ?`) will be taken at each telescope position (1 or 4).

  At the end of the template the telescope will offset again to return to its position at the beginning of the template.

4.7.3 VIMOS_img_cal_Astrom

VIMOS_img_cal_Astrom.tsf			
To be specified:			
Parameter	Hidden	Range *(Default)*	Label
DET.WIN1.UIT1	no	1..100000 *(NODEFAULT)*	Exposure time (seconds)
INS.FILT.NAME	no	U B V R I z Free *(NODEFAULT)*	Filter
SEQ.CAL.FLAG	no	1 4 *(1)*	1 or 4 quadrants?
SEQ.NEXPO	no	1..1000000 *(1)*	Number of Exposures per Telescope Offset ?
Fixed values:			
Parameter	Hidden	Value	Label
DET.READ.MODE	no	Medium	Readout mode
DET.WIN1.BINX	no	1	X binning factor
DET.WIN1.BINY	no	1	Y binning factor
INS.MODE	no	IMG	Instrument Mode
SEQ.HEADER	no	F	Header type

This template is for acquisition of astrometric data in Imaging mode. The acquisition template to use with this template is VIMOS_img_acq_Preset. The coordinates to define in the acquisition template are those of the astrometric field. Offsets from these coordinates to position the field in one or the four quadrants of the instrument will be applied automatically by the template.

The parameters of the template are:

- `Exposure time (seconds)`. This is the integration time in seconds per exposure.
- `Filter`. The available filters are: **U, B, V, R, I, z**. **To produce a valid calibration OB the filter in the first observation template following the acquisition template should be the same as the one in the acquisition template**.
- `Number of exposures per telescope offset ?`. This parameter defines how many exposures are taken at each offset position (1 or 4).
- `1 or 4 quadrants`. This parameter allows to define if the astrometric field image will be taken in 1 or 4 quadrants. If the **1 quadrant** option is selected, the astrometric field will be positioned in only one quadrant by applying an appropriate offset from the coordinates of the field defined in the target package of the acquisition template.

  If the **4 quadrant** option is selected, the astrometric field will be positioned sequentially in the 4 quadrants by applying the appropriate offsets from the coordinates of the field defined in the target package of the acquisition template.

  As many exposures as defined in (`Number of exposures telescopes offset ?`) will be taken at each telescope position (1 or 4).

  At the end of the template the telescope will offset again to return to its position at the beginning of the template.

4.7.4 VIMOS_mos_cal_NightCalib

VIMOS_mos_cal_NightCalib.tsf			
To be specified:			
Parameter	Hidden	Range *(Default)*	Label
SEQ.ARC	no	F T *(T)*	Night Arc ?
SEQ.FLATFIELD	no	F T *(T)*	Night Flat field ?
SEQ.NARCS	no	1..1000000 *(1)*	Number of Arcs ?
SEQ.NFLATS	no	1..1000000 *(3)*	Number of Flats ?
Fixed values:			
Parameter	Hidden	Value	Label
SEQ.HEADER	no	F	Header type

This template is to be used when screen flats or wavelength calibrations are needed during the night right after a science observation. **This template doesn't contain any setup definition and the data will be taken with exactly the same instrument setup as used in the previous science template**.

This template is to be used in a science OB **after** a science templates. It can not be used alone in an OB after an acquisition template. The exposure time parameters are automatically defined by the current instrument setup. The parameters of the template are:

- `Night Flat Field ? (T/F)`. If set to 'T', 3 screen flats will be taken.
- `Night Arc ? (T/F)`. If 'T' an arc spectrum will be taken.

4.7.5 VIMOS_mos_cal_Standard

VIMOS_mos_cal_Standard.tsf			
To be specified:			
Parameter	Hidden	Range *(Default)*	Label
DET.WIN1.UIT1	no	1..100000 *(NODEFAULT)*	Exposure time (seconds)
INS.FILT.NAME	no	U B V R I z OS-blue OS-red GG475 GG435 Free *(NODEFAULT)*	Filter
INS.GRIS.NAME	no	LR_blue LR_red HR_blue HR_red HR_orange MR *(NODEFAULT)*	Grism
INS.SLIT.NAID	no	0.8 1.0 1.2 1.5 1.8 2 2.5 5.0 *(1.0)*	Slit Width
SEQ.CAL.FLAG	no	1 4 *(1)*	1 or 4 quadrants?
SEQ.NEXPO	no	1..1000000 *(1)*	Number of Exposures per Telescope Offset ?
Fixed values:			
Parameter	Hidden	Value	Label
DET.READ.MODE	no	Medium	Readout mode
DET.WIN1.BINX	no	1	X binning factor
DET.WIN1.BINY	no	1	Y binning factor
INS.MODE	no	MOS	Instrument Mode
SEQ.HEADER	no	F	Header type

This template is used for the observation of a standard star in mode MOS. This template can only be used following the VIMOS_mos_acq_Standard acquisition template and **not** using the VIMOS_mos_acq_Mask. This template can only use the specifically designed standard mask from the repository.

The parameters of this template are:

- `Exposure time (seconds)`. This is the integration time in seconds per exposure.
- `Filter`. The available filters are: **U, B, V, R, I, z, OS-blue, OS-red, GG435, GG475**.
- `Grism`. The available grisms are: **LR_blue, LR_red, MR, HR_blue, HR_orange, HR_red**.
- `Number of exposures per telescope offset ?`. This parameter defines how many exposures are taken for each offset position.
- `1 or 4 quadrants?`. This determines whether the standard star will be positioned in one or four of the quadrants of the instrument. As many exposures as defined in (`Number of exposures per telescope offset ?`) will be taken at each telescope position (1 or 4).
- `Slit Width`. Define which of the slits available in the masks will be used. The width of the available slits are: **0.8, 1.0, 1.2, 1.5, 1.8, 2.0, 2.5, 5.0**. Once the user select the slit width the rest is totally automatic; the star will be offset from the acquisition box to the selected slit in the first quadrant and then moved to the same slit in the other quadrants.

4.7.6 VIMOS_ifu_cal_Specphot

VIMOS_ifu_cal_Specphot.tsf			
To be specified:			
Parameter	Hidden	Range *(Default)*	Label
DET.WIN1.UIT1	no	1..100000 *(NODEFAULT)*	Exposure time (seconds)
INS.FILT.NAME	no	U B V R I z OS-blue OS-red GG475 GG435 Free *(NODEFAULT)*	Filter
INS.GRIS.NAME	no	LR_blue LR_red HR_blue HR_red HR_orange MR *(NODEFAULT)*	Grism
INS.IFUE.NAME	no	0.33 0.67 *(0.67)*	IFU Magnification (arcsec/fiber)
INS.IFUS.MODE	no	T F *(F)*	IFU Shutter
SEQ.CAL.FLAG	no	1 4 *(1)*	1 or 4 quadrants?
SEQ.NEXPO	no	1..1000000 *(1)*	Number of Exposures per Telescope Offset ?
Fixed values:			
Parameter	Hidden	Value	Label
DET.READ.MODE	no	Medium	Readout mode
DET.WIN1.BINX	no	1	X binning factor
DET.WIN1.BINY	no	1	Y binning factor
INS.MODE	no	IFU	Instrument Mode
SEQ.HEADER	no	F	Header type

This template is used for the observation of a spectrophotometric standard star in IFU mode. It is to be used in a OB with the VIMOS_ifu_acq_Preset acquisition template.

The parameters of the template are:

- `Exposure time (seconds)`. This is the integration time in seconds per exposure.
- `Filter`. The available filters are: **U, B, V, R, I, z, OS-blue, OS-red, GG435, GG475**.
- `Grism`. The available grisms are: **LR_blue, LR_red, MR, HR_blue, HR_orange, HR_red**.

  In order to produce a valid OB the filter and the grism in the first observation template following the acquisition template should be the same as the one selected in the acquisition template.
- `IFU Magnification`. This parameter defines the sampling, and correspondingly the field of view of the IFU. The 2 available samplings are 0.67 arcsec/fiber and 0.33 arcsec/fiber.

  To produce a valid OB, the magnification should be the same in every template of the OB.
- `IFU Shutter`. This parameter is only meaningful when using the **LR** grisms. In **LR** spectroscopy, there are 4 rows of fibers along the dispersion direction, whereas in **MR** and **HR** modes only one 'slit' of fibers is used, hence the variation of field of view between **LR** and **MR** and **HR** modes. In case the object of interest is of limited size in **LR** mode, and if only the central $1/4 \times 1/4$ of the field of view is needed, it is possible with the `IFU Shutter` option to mask the outer part of the IFU (always masked in **MR** and **HR** modes). This allows to avoid second order overlap due to sky and / or background objects between the 4 adjacent slits along the dispersion direction. **True** means that the shutter is in place and masks the external part of the IFU, **False** (the default value) means that the mask is not in place and the full IFU field of view is available. **To produce a valid OB, the mask shutter option should be the same in every template of the OB**. This parameter is ignored when **MR** or **HR** grisms are used.

- `Number of exposures per telescope offset ?`. This parameter defines how many exposures are taken for each offset position.
- `1 or 4 quadrants?`. This determines whether the standard star / field will be positioned in one or four of the quadrants of the IFU. As many exposures as defined in (`Number of exposures per telescope offset ?`) will be taken at each telescope position (1 or 4).

4.7.7 VIMOS_ifu_cal_NightCalib

VIMOS_ifu_cal_NightCalib.tsf			
To be specified:			
Parameter	Hidden	Range *(Default)*	Label
SEQ.ARC	no	F T *(T)*	Night Arc ?
SEQ.FLATFIELD	no	F T *(T)*	Night Flat field ?
SEQ.NARCS	no	1..1000000 *(1)*	Number of Arcs ?
SEQ.NFLATS	no	1..1000000 *(3)*	Number of Flats ?
Fixed values:			
Parameter	Hidden	Value	Label
SEQ.HEADER	no	F	Header type

This template is to be used when screen flats or wavelength calibrations are needed during the night right after a science observation. **This template doesn't contain any setup definition and the data will be taken with exactly the same instrument setup as used in the previous observation template**.

This template is to be used in a science OB **after** observation templates. It can not be used alone in an OB after an acquisition template. The exposure time parameters are automatically defined by the instrument setup. The parameters of the template are:

- `Night Flat Field ? (T/F)`. If set to 'T', 3 screen flats will be taken.
- `Night Arc ? (T/F)`. If 'T' an arc spectrum will be taken.

4.7.8 VIMOS_ifu_cal_TwFlat

VIMOS_ifu_cal_TwFlat.tsf			
To be specified:			
Parameter	Hidden	Range *(Default)*	Label
DET.WIN1.UIT1	no	1..100000 *(NODEFAULT)*	Exposure time (seconds)
DPR.CATG	yes	CALIB TEST *(CALIB)*	
INS.FILT.NAME	no	U B V R I z OS-blue OS-red GG475 GG435 Free *(NODEFAULT)*	Filter
INS.GRIS.NAME	no	LR_blue LR_red HR_blue HR_red HR_orange MR *(NODEFAULT)*	Grism
INS.IFUE.NAME	no	0.33 0.67 *(0.67)*	IFU Magnification (arcsec/fiber)
INS.IFUS.MODE	no	T F *(F)*	IFU Shutter
SEQ.NEXPO	no	1..1000000 *(1)*	Nunber of Exposure?
Fixed values:			
Parameter	Hidden	Value	Label
DET.READ.MODE	no	Medium	Readout mode
DET.WIN1.BINX	no	1	X binning factor
DET.WIN1.BINY	no	1	Y binning factor
INS.MODE	no	IFU	Instrument Mode
SEQ.HEADER	no	F	Header type

This template is used for the observation of twilight flats in IFU mode. **It is only offered in visitor mode.** It should go together with an attached arc.

The parameters of the template are:

- `Exposure time (seconds)`. This is the integration time in seconds per exposure.
- `Number of exposures?`. This parameter defines how many exposures are taken.
- `Filter`. The available filters are: **U, B, V, R, I, z, OS-blue, OS-red, GG435, GG475**.
- `Grism`. The available grisms are: **LR_blue, LR_red, MR, HR_blue, HR_orange, HR_red**.
- `IFU Magnification`. This parameter defines the sampling, and correspondingly the field of view of the IFU. The 2 available samplings are 0.67 arcsec/fiber and 0.33 arcsec/fiber.

  To produce a valid OB, the magnification should be the same in every template of the OB.
- `IFU Shutter`. This parameter is only meaningful when using the **LR** grisms. In **LR** spectroscopy, there are 4 rows of fibers along the dispersion direction, whereas in **MR** and **HR** modes only one 'slit' of fibers is used, hence the variation of field of view between **LR** and **MR** and **HR** modes. In case the object of interest is of limited size in **LR** mode, and if only the central $1/4 \times 1/4$ of the field of view is needed, it is possible with the `IFU Shutter` option to mask the outer part of the IFU (always masked in **MR** and **HR** modes). This allows to avoid second order overlap due to sky and / or background objects between the 4 adjacent slits along the dispersion direction. **True** means that the shutter is in place and masks the external part of the IFU, **False** (the default value) means that the mask is not in place and the full IFU field of view is available. **To produce a valid OB, the mask shutter option should be the same in every template of the OB**. This parameter is ignored when **MR** or **HR** grisms are used.

Chapter 5

Guidecam Tutorial

This chapter contains the information about the Guidecam software tool, which was in the past present as a separate document entitled "Vimos Guidecam User Manual," VLT-MAN-ESO-14610-3512, written by S. Brillant.

Note that users wanting to take advantage of the new pre-imagless MOS mode should use the new PILMOS application (*instead of) the Guidecam application. The PILMOS application is essentially an enhanced version of the Guidecam application that allows field and guide star selection in exactly the same way as described in this chapter but also has some additional functionality for creating VIMOS catalogues and simulated pre-images from contributed catalogues. See the instructions in Chapter 7.*

5.1 Getting started with Guidecam

Using Guidecam is fairly simple:

- Start Guidecam by issuing the command `guidecamLite` after installation. This opens up a skycat GUI with a specific `Guide-Probe` pull-down menu. Figure 5.1 shows the main Guidecam panel.
- Select the `Settings` option of the `Guide-Probe` menu. This opens up the `Guide Probe Settings` panel which is represented in Figure 5.2
- Enter the coordinates of the target in the 'Telescope' section of the panel. Note that the coordinates have to be in J2000, and the format should be as indicated. For pre-imaging observations preparation the default value of 90 degrees for the rotation angle on sky **should not be modified** unless a waiver is requested.

  When pressing the **Apply** button, Guidecam will download from the ESO archive the DSS image of the field and open a panel `USNO at ESO` displaying the USNO star catalog of the field. This panel is represented figure 5.3. **Allow for a few seconds to a few tens of seconds for the image to be downloaded**.
- At this point on, it is possible to position the Guide Probe on the available catalog stars and to evaluate if vignetting occurs.

5.2 The main 'Guidecam' GUI

The Guidecam GUI (figure 5.1) displays:

- the image of the field
- the projected shadow of the Telescope Guide Probe (yellow) onto the telescope focal plane

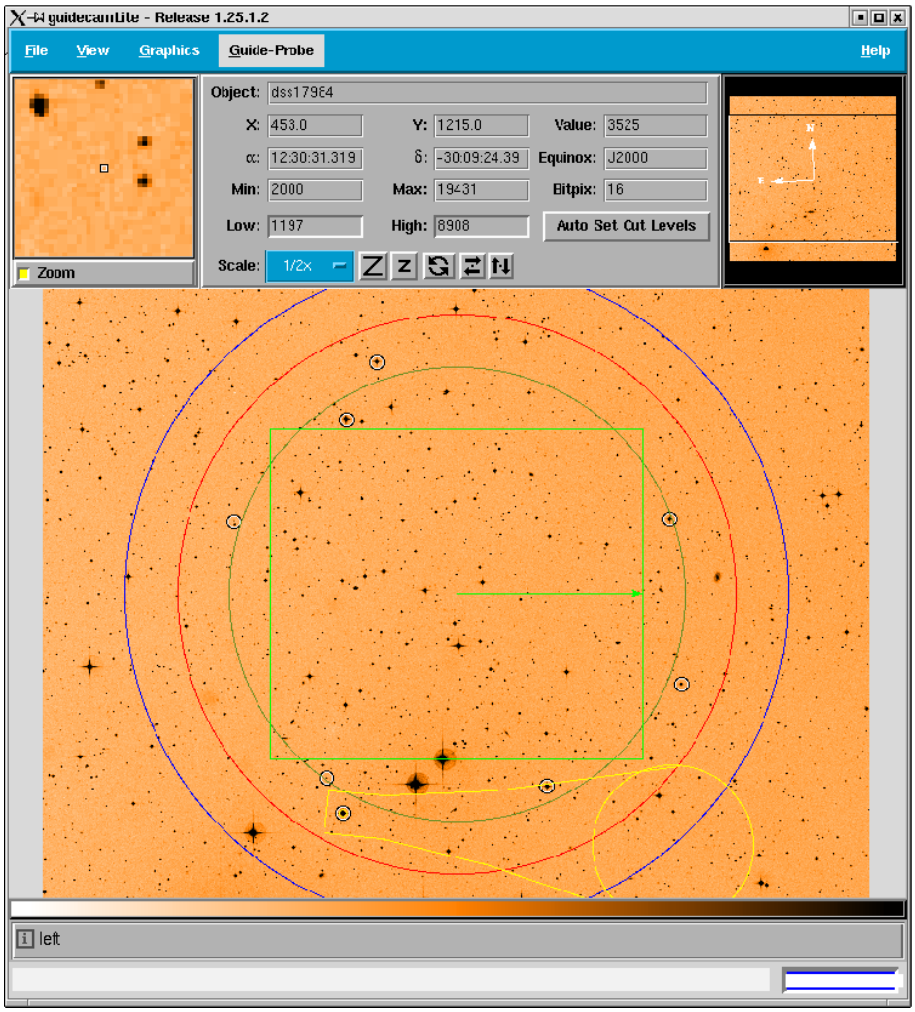


Figure 5.1: Guidecam main panel (skycat). Superimposed to the DSS image of the field is in yellow the projected shadow of the Telescope Guide Probe, in green the VIMOS field of view (rectangle), and in green and red the 11 and 13.5 arcminute radii corresponding respectively to the unvignetted Nasmyth field of view and to the maximum search radius for guide stars

- the VIMOS field of view (green), with the arrow pointing to the N
- a circle of 11 arcminutes radius (green) corresponding to the unvignetted telescope focal plane. Beyond this radius there is vignetting by the tertiary mirror of the telescope
- a circle of 13.5 arcminute radius (red) corresponding to the maximum search radius for guide stars
- in blue the rotation axis of the Guide Probe arm
- the position of the USNO stars selected in the `USNO at ESO` panel (figure 5.3). The stars are indicated with white circles.

5.3 The 'USNO at ESO' panel

The `USNO at ESO` panel (figure 5.3) provides for the following entries:

- Search radii (min and max). The default value for the maximum radius is 12 arcminutes with a maximum permitted value of 13.5. Below 11 arcminutes, i.e., within the green circle, the Nasmyth field of

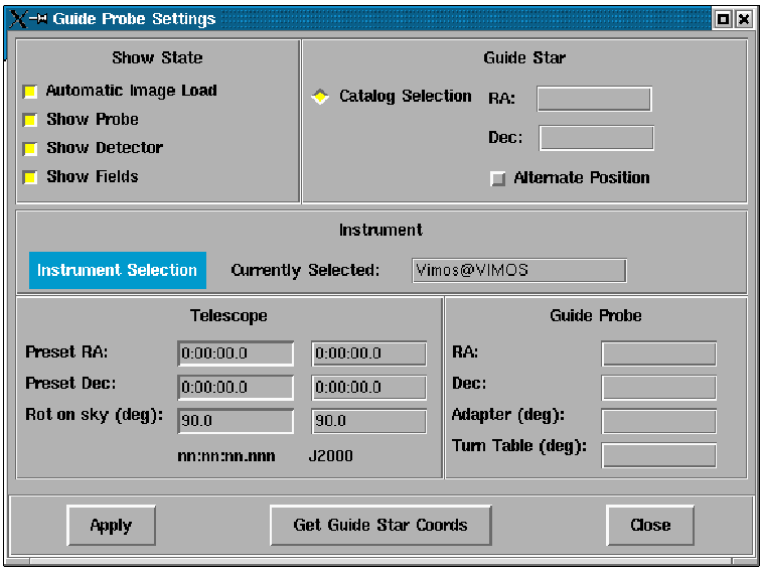


Figure 5.2: Guidecam: the `Guide Probe Settings panel`

view is vignetted by the tertiary mirror (M3) of the telescope. Therefore the aberrations of the telescope cannot be measured with the same accuracy. In some cases, this may degrade the image quality.

- Magnitude range. The default minimum and maximum values are 11 and 13.5 whereas the minimum and maximum permitted values are 10 and 14. With the faintest guide stars, some degradation of the active optics correction might take place, depending on seeing, airmass, Moon, possible extinction by thin cirruses, and position of the guide star in the field of view (vignetting beyond 11 arcminutes). To the extent this is possible, stars brighter than 13.5 magnitude should be chosen. Too bright objects may result in poorer correction as well.

- In the "USNO at ESO" pane, the maximum number of objects can be changed to either limit or increase the number of stars to be displayed

Note : whenever a value is changed and entered a new search takes place and the results are displayed on the images while the updated list of stars appears on the `Search Results` panel. Pressing the **Search** button after changing more than one value will also start a new search and display the results.

5.4 Selecting the Guide Star

To select a guide star:

- Click with the left mouse button on one of the white circles identifying the USNO stars

- This opens a small panel asking **Move to the selected guide star?**. Pressing **Accept** will move the guide probe to the star. Vignetting of the VIMOS field of view takes place whenever the guide probe (yellow) intercepts the VIMOS field of view (green rectangle). If there is vignetting, it is possible to select another star and to repeat the operation, until a suitable guide star is found.

- The guide probe can be positioned on a given guide star in 2 positions (called positive and negative (POS and NEG)). This is referenced to as **Alternate position**. By selecting the corresponding button in the `Guide Probe Settings` panel (figure 5.2) and pressing the **Apply** button, the guide probe will be positioned on the same star on its alternate position. This option may allow to reduce or even remove the vignetting that may be present in the other position.

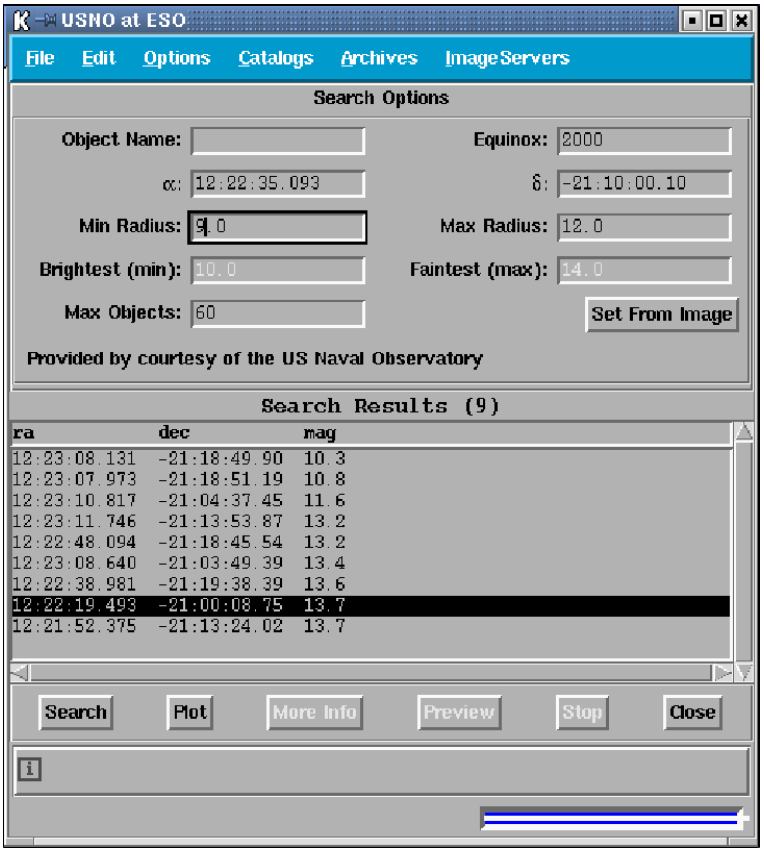


Figure 5.3: GuideCam: the `USNO at ESO` panel

- Once a suitable guide star has been identified, you can take note of its position by pressing the **Get Guide Star Coords** of the `Guide Probe Settings` panel. This popups an information panel containing the RA and DEC of the selected guide star and indicating whether the position of the guide probe is positive or negative (alternate position). These coordinates, as well as the guide probe position, should be noted and further entered manually into P2PP in the corresponding fields: `Guide Star RA`, `Guide Star DEC` and `Guide Probe Position` of the VIMOS_img_acq_Preset template. Finally, the `Get Guide Star From` should be set to **SETUPFILE** (see VIMOS Template Reference Guide).

5.5 Generating Finding Charts

Guidecam should be used to generate finding charts for VIMOS imaging and pre-imaging modes. Under the `File` menu, select the `Make finding charts...` option. A new pop window will appears, to be filled with Run ID, P.I. name, and OB name(s). Click on **Draw** to obtain a preview of a finding chart compliant with the rules defined for phase 2 proposal preparation, Then, press **Save** to produce a postscript file. Detailed and updated instructions are given at

`http://www.eso.org/observing/p2pp/P2PP-FC-cookbook.html`

5.6 Guide Stars: Policy

Starting from P72, ESO applies the following policy regarding guide stars:

- Selection of a Guide Star for VIMOS observations is **mandatory** for MOS and IMG mode, to assess

and control the amount and position of vignetting that may be introduced by the Guide Probe. When the guide star is selected, the coordinate should be properly entered in the acquisition template, together with the position of the guide probe, and the guide star option have to be selected properly (see 4.4). **If this is not done properly your OB will not pas validation and will not be scheduled for observation. See Phase 2 Web pages for detailed information.**

- In case of observation involving offsets, it is the responsibility of the user to check with guidecam that the chosen guide star does not produce unacceptable vignetting in any of the frame produced by the execution of the OB. **ESO will consider as executed within specification an OB producing vignetted frames, implicitly assuming that the vignetting was already verified by the user.**

- If no guide star is provided by the user (i.e. the option **CATALOGUE** of the `Get Guide Star From` P2PP parameter of the VIMOS_ifu_acq_Preset template is selected), the guide star will be selected by the Telescope Operator at execution time.

- If the user provides a guide star (by selecting the option **SETUPFILE** of the `Get Guide Star From` P2PP parameter of the VIMOS_img_acq_Preset template), efforts will be made to use this guide star for imaging, pre-imaging and for the subsequent MOS observations, although this cannot be entirely guaranteed. Observing conditions (seeing, Moon, etc.) may indeed force to select a different guide star than the one selected by the user. In addition, it may happen that a guide star suitable for pre-imaging observations will not be usable for the spectroscopic follow-up if e.g. the seeing has changed. **ESO reserves the right to charge to the time allocated to the run the time spent in identifying and setting up the alternative guide star.**

- The use of the guidecam tool is mandatory also for the preparation of the finding charts to be delivered as part of their Phase II material. The finding charts should clearly indicate the guide star to be used.

Chapter 6

VMMPS Tutorial

6.1 The VMMPS philosophy

This chapter contains the info from the VMMPS Cookbook by M. Kissler-Patig and G. Marconi, VLT-MAN-ESO-14610-3511 formatted to fit in this manual.

6.1.1 What does VMMPS do?

VMMPS is a software that, in the end, produces a file that you must attach to any of your VIMOS multi-object spectroscopy OBs. That file, called Aperture Definitions in Pixels (ADP) file, contains the list of all slits (positions, sizes, shapes) that will be milled into that particular mask. The file contains this information in pixels coordinates, and hosts in addition the transformation (that it got from the pre-image header) on how to transform that particular x,y values into millimeters on the mask. Further, that file has as well all the necessary pointing information obtained from the pre-imaging.

Creating these ADP files is your goal. As an input, you need the VIMOS pre-image and a catalog of objects. And how to get from there to your desired output product is all explained step by step below...

NOTE that VMMPS handles separately each quadrant. You will have to run VMMPS 4 times to produce one full set of masks to be attached to 1 OB (the software helps you somewhat to do that). The important point here is that you will have to prepare for VMMPS an input set (catalogs(s) and image) for each quadrant.

6.1.2 This is *not* FIMS - you have little chance for interaction

Many MOS users will be familiar with FIMS, the software that helps you defining masks for FORS. VMMPS is very different. The main reason being that VMMPS was conceived as a tool to define masks for surveys. Unlike FIMS it will hardly allow you to allocate slits manually. Instead, it will automatically optimize the slit assignment for object in your catalog. Of course, you can pick some or even all objects by hand, but it will cost you time and nerves and the allocation will not be optimized in terms of numbers. It is long term objective of ESO to harmonize the mask preparation tools between VIMOS and FORS after a few periods of VIMOS observations, of experience and of feedback from the users.

At the heart of vmmps is SPOC, the Slit Positioning Optimization Code, described by Bottini et al. (PASP 117, 996 (2005)). Given a catalog of objects, SPOC maximizes the number of observable objects in a single exposure and computes the corresponding slit positions. It does so by solving a very complex 2D combinatorial problem.

6.1.3 The importance of your catalog

VMMPS fully relies on your **catalog** to contain exactly the objects that you want to observe. In VMMPS you have hardly any freedom to set priorities for your preferred objects. Your catalog should contain all and only the objects you really want to observe. VMMPS will optimize the allocation of slits for you such as to *maximize the number of objects observed from your catalog*, assuming that you have no favorites.

In summary, VMMPS relies *heavily* on your catalog. Thus, instead of using your brain intensively while running VMMPS, rather *use your intellectual power and scientific judgment to create a smart input catalog*. Your catalog is the most important item in the process.

6.1.4 The different catalogs that you can come with

We distinguish between two different scenarios.

1. **Contributed + pre-image catalog case** Prior to pre-imaging with VIMOS you know already which objects you want to obtain spectroscopy for and have precise astrometry for them. E.g. you were running an imaging survey with a wide field imager and have identified your candidates on a given astrometric system.

   This catalog must have precise *relative* astrometry for all objects **and** for a number of reference stars. It is important that the astrometry of the science objects and the reference stars are on the same system. You will now obtain pre-imaging with VIMOS, extract from there a short list of objects detected on the VIMOS image (the `VIMOS pre-image catalog`) and VMMPS will help you to bring your `contributed catalog` onto the VIMOS coordinate system.

2. **VIMOS catalog case** You only know which objects or type of objects you are after, but have no list with precise RA,DEC for your objects. E.g. you rely on the VIMOS pre-image to determine the objects you will obtain spectroscopy for.

   This catalog is obtained directly from the VIMOS image using your favorite analysis tools [1]. It takes coordinates in detector x,y as well as any other parameter you want to convey and can be used right away by VMMPS (provided that it has the right format, see below).

3. **PILMOS case** Chapter 7 describes the pre-imagless MOS mode that is available since June 2012.

   VMMPS handles this case in the same way as the **Contributed + pre-image catalog** case. PILMOS essentially provides an alternative way to arrive at Step 3 (6.2.4) below. We nevertheless encourage PILMOS users to read through the full procedure in this chapter as well as Chapter 7 in order to gain an understanding of the requirements and assumptions of both strategies.

[1] We recommend Sextractor (Bertin & Arnouts 1996, A&AS 117, 393) without getting any royalties for it, but because it serves well the purpose and you will recognize some similar structures/parameters

6.2 Step-by-step guide

6.2.1 Step 0 (most crucial): Getting ready – preparing your catalogs

This step is done outside VMMPS. But as mentioned above, it is the most important one.

What you need

- **for each quadrant** one VIMOS pre-image processed by the ESO pipeline, and
- EITHER **for each quadrant** a `VIMOS catalog`
- OR a `contributed catalog` (it can be one catalog including objects on all 4 quadrants, or be four catalogs – one per quadrant), *together* with, **for each quadrant** a `VIMOS pre-image catalog`

The format of the catalogs

All catalogs accepted by VMMPS have plain ASCII format. **The file name should not use the extension .dat as this causes the program to crash.** Use of .cat or .data should work.

Some example are given in Section 6.4.

The input format is:

- a header line with column names in upper case.

  There is no preferred order for the columns, but see below for mandatory and reserved columns and names.

  The first line is interpreted as the header line.

  Header entries are separated by any number of blanks or tabs.

  A <return> marks the end of the header line.

- the data sorted in columns.

  Columns on a given row are separated by any number of blanks/tabs.

  The number of columns and their order is defined by the number of entries and their order in the header. No empty field is allowed, you will get a friendly warning if some are present.

  The first row after the header line defines the beginning of the data, the last row defines the end of data. Each row must end with a <return>.

  Note that no blank lines are allowed in the catalogs, and you will get a friendly warning if any is present.

Getting your `contributed catalog` into the right format

Assuming that you are in case 1, you need to prepare the two catalogs described in the this and the next section.

The contributed catalog contains all the objects that you wish to observe, plus (or including) enough bright objects that can serve for the cross-correlation with the VIMOS pre-image catalog and as reference stars for aligning the mask on the sky. All objects shall have very good ($\pm$0.1") *relative* astrometric coordinates (RA,DEC) on a single astrometric system. Further, all objects should have good ($\pm$2") absolute astrometry.

The **mandatory columns** in the contributed catalog are (in upper case and in the following order):

- ID defining an identifier which *must be unique and integer number*.
- RA, the right ascension of the object.
- DEC, the declination of the object. RA and DEC entries are allowed in 2 formats:

  - decimal degrees

  - hh:mm:ss.s (including semi-colons)

The **optional columns** whose names are reserved are:

- CROSS is, for each object, either 1 if that object shall be used for the cross correlations, or 0 if it shall not (e.g. if it is too faint, too elongated, ...). We recommend not to flag more than 500 stars with CROSS=1.
- FLAG shall be one of (upper or lower case) C - compulsory[2]; R - reference; F - forbidden; S - select-able (no blank entry is supported, any other flag will be replaced by S - select-able)
- A_ARCSEC the semi-major axis in arcsec
- B_ARCSEC the semi-minor axis in arcsec
- PA the position angle (E of N in degrees)

  The latter three will be used to compute the object size in pixels along the x direction of the detector (i.e. along the slit).

Any other columns whose names do not match the above ones.

Notice only that the names X_IMAGE and Y_IMAGE are **forbidden** in the `contributed catalog` – they are used/computed later. If these are present, the software will kindly reject your catalog until you removed them.

All columns present in the `contributed` (input) catalog will be carried over to the output catalog. Some columns will be used to generate new columns in the output catalog (see below Step 2).

The example of a `contributed catalog` is given in Section 6.4.1.

[2]Sometimes a large number of "C" compulsory targets in the input catalogue results in crashing VMMPS during slit assignment. See Sec. 6.3.2.

Preparing your `VIMOS pre-image catalog`

The `VIMOS pre-image catalog` accompanies the `contributed catalog` with the only purpose to transform the RA,DEC coordinates into x,y coordinates. This automatically corrects for any distortion in the VIMOS optics, and most importantly for the mask manufacturing: for x,y the transformation into mm on a physical mask is known (we have determined that for you and stored the information in the pre-image header).

You need in the `VIMOS pre-image catalog` a small number (e.g. 50 or more) of objects that are also in your `contributed catalog`. In the `VIMOS pre-image catalog` you shall have the x,y coordinates of these objects obtained from exactly the same VIMOS pre-image as you will input into VMMPS. Note that the more good objects are in common between the two catalogs, the better the result of the cross-correlation, i.e. the transformation from RA,DEC to pixels will be.

Since the objects will be used for cross-correlation, their position in pixel coordinates shall be as good as possible. Therefore, make sure that you selected bright (S/N>10), unsaturated, if possible point like objects on the VIMOS pre-image.

This comparatively short list of objects shall be written in an ASCII file with the **mandatory columns** (in upper case, and in the following order):

- ID an identifier which *must be unique and integer number*,
- X_IMAGE the x–coordinate in pixels on the VIMOS pre-image
- Y_IMAGE the y–coordinate in pixels on the VIMOS pre-image

Any other column is allowed but will be ignored and not carried over to the output catalog of the cross-correlation (see Step 2).

The example of a `VIMOS pre-image catalog` is given in Section 6.4.

Getting your `VIMOS catalog` into the right format

Assuming that you are in case 2, you only need to prepare a `VIMOS catalog`.

The VIMOS catalog can:

- either be obtained as an output of the cross-correlation task (in which case you do not have to worry: it will have the right format)
- or be produced directly by the user (that's you) from the VIMOS pre-image.

The **mandatory columns** are (in upper case and in the following order):

- ID an identifier which *must be unique and integer number*,
- X_IMAGE the x–coordinate in pixels on the VIMOS pre-image
- Y_IMAGE the y–coordinate in pixels on the VIMOS pre-image

The **optional columns** whose names are reserved are:

- FLAG shall be one off C - compulsory[3]; R - reference; F - forbidden; S - select-able (no blank entry is supported, any other flag will be replaced by S - select-able)
- X_WORLD
- Y_WORLD, the coordinates of the object in the world coordinate system (not used by VMMPS)
- A_IMAGE the semi-major axis in pixels
- B_IMAGE the semi-minor axis in pixels
- THETA_IMAGE the position angle (in degrees positive x-axis is 0, positive counter-clockwise) of the object
- X_RADIUS the object size in the x (spatial) direction of the detector.

A_IMAGE, B_IMAGE and THETA_IMAGE are used to compute X_RADIUS. The column X_RADIUS is used when one or more of A_IMAGE, B_IMAGE, THETA_IMAGE are not given, otherwise it is overwritten. If X_RADIUS, and any one of A_IMAGE, B_IMAGE, THETA_IMAGE is missing, the object size in x is set to 10 pixels. If X_RADIUS > 45 pixels, the object is automatically flagged as forbidden by the software. [4]

Any other columns can be added with any names. The catalog later allows to constrain with any number of criteria on any number of columns the select-able objects. So typically, you might want to add color, magnitude or may other columns that you might want to use as selection criteria to the catalog.

An example is given in Section 6.4.

[3] Sometimes a large number of "C" compulsory targets in the input catalogue results in crashing VMMPS during slit assignment. See Sec. 6.3.2.

[4] The reason for this is that the manufacturing machine can cut slits of max. 20" length, which translate into 150 pixels, and that you are allowed to add 10" (50 pixels) sky on each side.

Getting your input VIMOS `pre-image` ready

Good news: your VIMOS pre-image processed by the ESO pipeline is ready as it is to be accepted by VMMPS.

Bad news: if your image is not a VIMOS `pre-`image, or if the VIMOS pre-image was not processed by the ESO pipeline, or if you had the bad idea to modify the pre-image even in the slightest detail (e.g. you had 3 dithered pre-images and combined them), etc... VMMPS will not work, or in the worse case will seem to work but you will never see your objects through your slits. Indeed, your x,y coordinates will be transformed into mm for the mask manufacturing using the transformation in the image header, assuming that we deal with original x,y system. If you have translated, re-scaled, re-binned the image, this transformation will not be valid anymore.

Just make sure that your input to VMMPS is an original, untouched VIMOS pre-image processed by the ESO pipeline. Also make sure that this pre-image is the one you used to obtain the coordinates for your `VIMOS pre-image catalog` or `VIMOS catalog`.

If you would like to learn a little about the background of all this, read further this section. If you are just lazy and happy with the information so far, go ahead and jump now to Step 1.

Some Background: One of the VIMOS calibrations consists of using a pinhole mask to determine accurately the transformation between millimeters on mask and coordinates on the CCD (we know at which mm we cut the holes in the mask, and we measure the x,y coordinates of the holes on the image processed by the ESO pipeline). This transformation is stored and updated on the instrument workstation. Now, when your VIMOS pre-image gets taken, this transformation, valid at that particular moment, is stored in the header of your VIMOS pre-image. Thus, with the help of that transformation, you (or rather VMMPS) know how to go from the x,y coordinates of that image to position in mm on the mask (i.e. position on the focal plane). The combination of the transformation in that header and the coordinates in that image allows to determine the precise mm coordinates for the mask. Should you use transformation and x,y from different images, the result would not be correct anymore. Thus the importance to derive the coordinates from exactly the image that will be fed to VMMPS and from which the transformation will be taken.

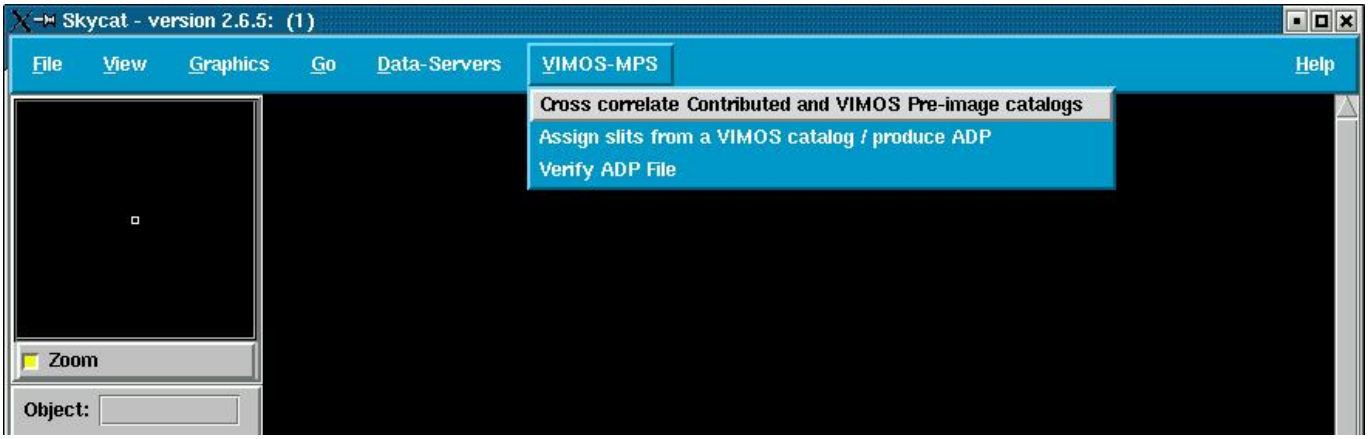
6.2.2 Step 1: What is your starting point?

Are your sure you fulfilled Step 0? If you have not suffered at least a little bit while preparing your catalog, if you have not thought twice whether you had the right objects in there, there is a good chance that you will suffer a serious headache before Step 8. So take your time re-thinking about your catalog. Read through Step 0 again, it is worth it, we believe that it will actually *save* you time.

OK, enough warnings, if you went carefully through Step 0, you are ready to start VMMPS. To do so, type:

```
> vmmps &
```

and you should see the following window pop-up (if you are a regular skycat/RTD user, this will look very familiar to you, but notice the new plug-in in the top bar – 'VIMOS-MPS' or VMMPS for people who like acronyms of acronyms):



What to do next depends on the type of catalog you have prepared.

You have your own "pre-VIMOS" catalog: the `contributed catalog` case

• proceed with Step 2

The VMMPS task of defining slits only accepts `VIMOS` catalogs, and you need to produce one. Do not panic, VMMPS has a built-in task to help you doing so using your `contributed catalog` together with a `VIMOS pre-image catalog` and a VIMOS pre-image.

What you have is a list of RA and DEC of your objects (a `contributed catalog`), and the VIMOS pre-image freshly out of the ESO pipeline. Make sure that the relative astrometry in your catalog is very good and that your list actually also contains, on the same astrometric system, a good number of objects that appear on the VIMOS pre-image (e.g. a list of only $z = 6$ emission line galaxies will probably *not* allow you to do a nice cross-correlation with the VIMOS pre-image catalog – you might want to add a few $V = 12 - 16$ mag stars).

Run your favorite source detection algorithm on the original, pipeline processed VIMOS pre-image. Make sure that you retain only point source with S/N>20 or so, and store all this in a `VIMOS pre-image catalog`.

Make sure that you prepared the three above ingredients according to Step 0, and move now to Step 2.

Your catalog comes from a VIMOS pre-image: the `VIMOS catalog` case

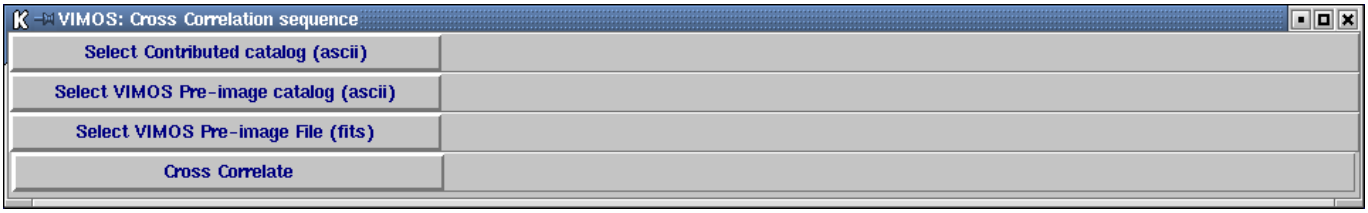
• Jump to Step 3

If you are sure that you have a `VIMOS` catalog for each quadrant fulfilling the requirements of Step 0, just identify the corresponding associated VIMOS pre-image for each of the 4 quadrants. You are ready to jump right into the mask definition, move to Step 3.

6.2.3 Step 2: Transforming your `contributed` catalog into a `VIMOS catalog`

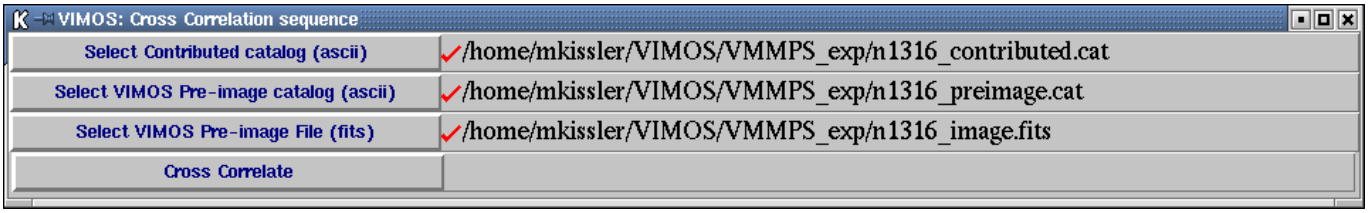
This is a necessary step, but quite painless if you followed the instructions of Step 0.

From the pull-down menu 'VIMOS-MPS' (see Step 1), select the task 'Cross correlate Contributed and VIMOS pre-image catalogs'. You will see popping up the following 'VIMOS: Cross Correlation sequence' window (here under KDE/Linux):


VIMOS: Cross Correlation sequence
Select Contributed catalog (ascii)
Select VIMOS Pre-image catalog (ascii)
Select VIMOS Pre-image File (fits)
Cross Correlate

This window asks you to input (in that order) the catalogs and the image. Just click from top to bottom and follow the instruction. Once you have filled the last item:

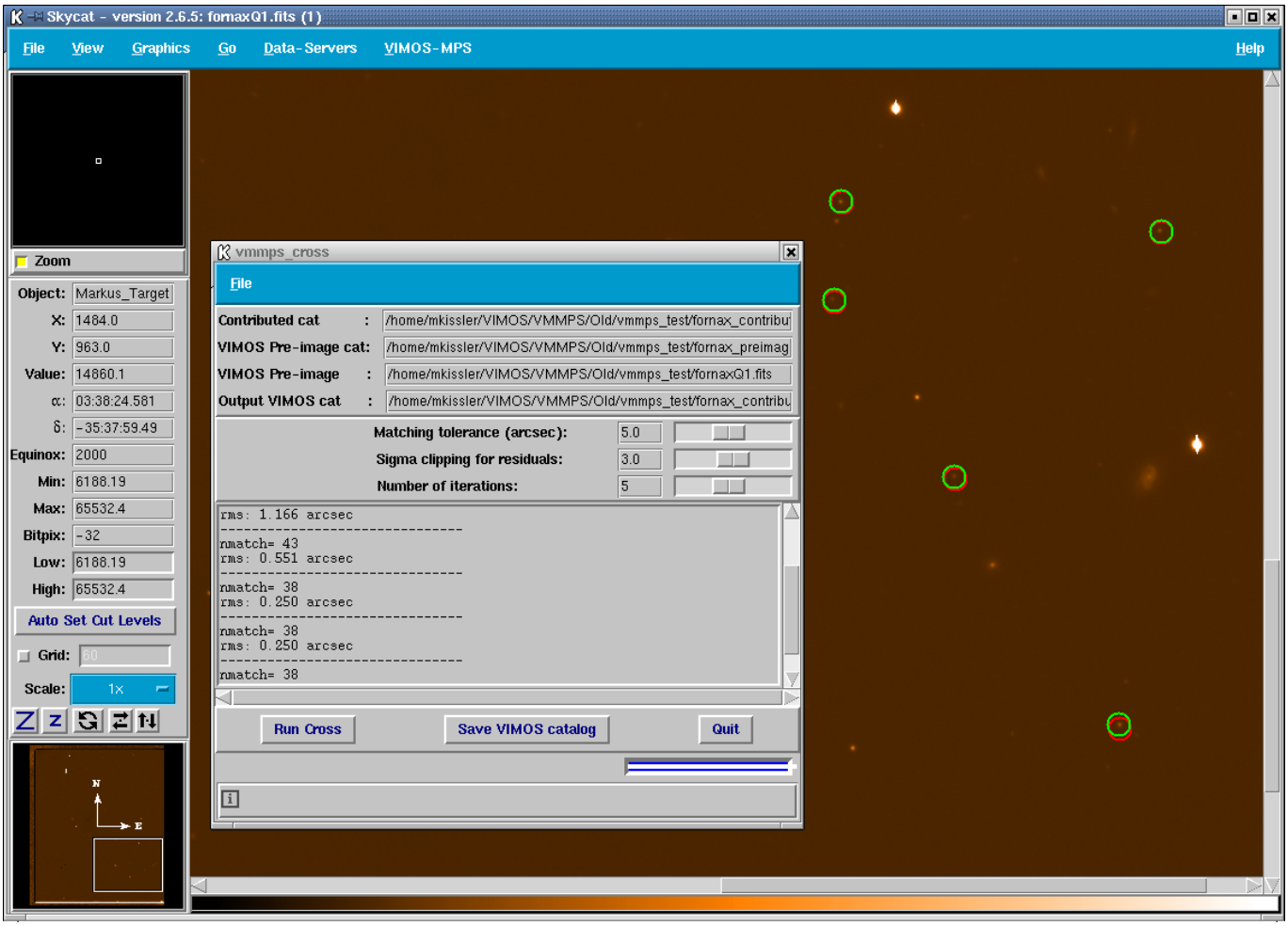
- that window will look as shown below,
- the selected VIMOS pre-image will appear in the display



and after you have clicked on the button 'Cross-correlate':

- the above window will disappear, and
- the window 'vmmps_cross' will pop-up

You will then get something like this:



The 'vmmps_cross' window summarizes your input (top part) and awaits your tuning of the cross-correlation parameters. At the beginning, the bottom part is empty.

The cross-correlation parameters are:

- **the matching tolerance in arcsec**: what is the maximum difference in position that you want to allow between VIMOS pre-image and contributed catalog to still consider two objects to be the same?

  If your astrometry in the contributed catalog is perfect, pick a small value (you are sure that if VIMOS pre-image and contributed catalog position do not agree by say 2" the objects cannot be the same). Remember, however, that the VIMOS pre-image suffers from optical distortion, differential atmospheric refraction etc, i.e. the position in the VIMOS pre-image catalog will not be perfect.

  If you suspect the absolute astrometry of your contributed catalog to have a systematic offset, use a larger value (e.g. 5"). This should take care of it and allow to find matching stars. The danger are mis-identifications: if the RMS of the final transformation is large, this might have happened. Try then to go back to smaller values.

- **the Sigma clipping for residuals**: the task will find a number of objects in common between VIMOS pre-image and contributed catalog. It will compute the position difference in the two catalogs and some objects (e.g. mismatches) will show high values. Define with this parameter when such an object will be rejected from the final fit.

- **the Number of iterations**: the task will compute a first transformation for the objects in the contributed catalog, applied it and if the number of iterations is > 1 restart the cross-correlation to compute a new transformation. Depending on the number of out-layers, distortions in the field, the final transformation might significantly improve with a few iterations. If you see no clear improvement in RMS between two successive passes, you probably reached the necessary number of iterations.

Once you have set the parameters, click 'Run Cross' to run the cross correlation. You will get the log/output of the task display in the lower part of the window.

The log tells you how many objects were found in your VIMOS pre-image (nref) and contributed (ncross) catalog, respectively. Do not forget that you can set a column CROSS in your contributed catalog and only the objects with CROSS=1 will be used for the matching and counted in ncross. E.g. you can safely put any faint high-z galaxy to CROSS=0 in the contributed catalog since it is unlikely to find a match in the VIMOS pre-image catalog. We recommend to flag fewer than 500 stars with CROSS=1 in the contributed catalog otherwise the cross-correlation procedure can crash.

On the display, you will find marked the objects finally used for the transformation `nmatch` (green), as well as the objects that were found to have a counter-part in the first pass but were rejected later (red). This helps you to visually inspect whether the task did something meaningful.

The log tells you further, for each iteration, how many objects were found to match, and what the RMS of the transformation (in arcsec) is for these objects.

You can readjust the parameters and run the task again and again and again until you are satisfied (if you cannot reach that spiritual stage, press 'Quit'). Once you are happy with the precision of the transformation (we recommend a RMS of the order of 0.2" or lower), click on 'Save Vimos Catalog' and, guess what, it will save your contributed catalog as a VIMOS catalog. The **name of the output** is composed of the name of your `contributed catalog` followed by `_vm.cat`, that is

`<name of contributed catalog>_vm.cat`.

You can now use this catalog to define slits (Step 3).

A brief word on the output: it has a format complying with the one described in Step 0. It will contain all the objects of your contributed catalog. It will still have all the columns that you defined in the contributed catalog, **plus** two columns (X_IMAGE, Y_IMAGE) giving in pixels the object coordinates in the reference system of the pre-image. The advantage is that these latter coordinates can now be transformed into mm in the focal plane, i.e. mm coordinates on the mask, by using the CCD-to-Mask transformation present in the header of the pre-image.

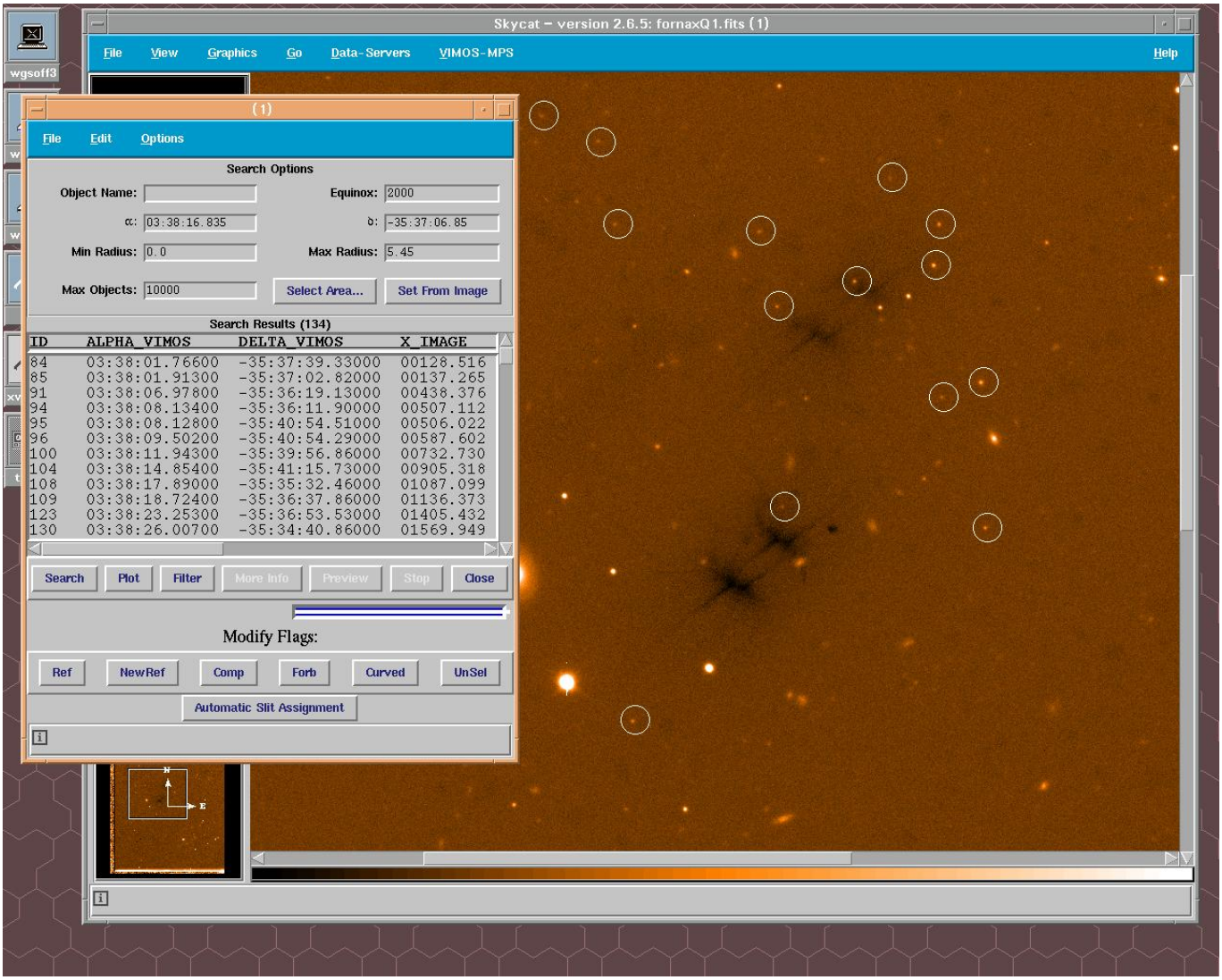
6.2.4 Step 3: Starting VMMPS for mask definition

At the beginning of this step, make sure that your display is blank (safest way) by selecting 'Clear' in the 'File' pull-down menu of `skycat` or be sure that the image displayed is indeed the pre-image that you want to use for this step.

You have your VIMOS catalog ready? Then go ahead and selected in the main window from the pull-down menu 'VIMOS-MPS' the task 'Assign slits from a Vimos catalog / produce ADP'.

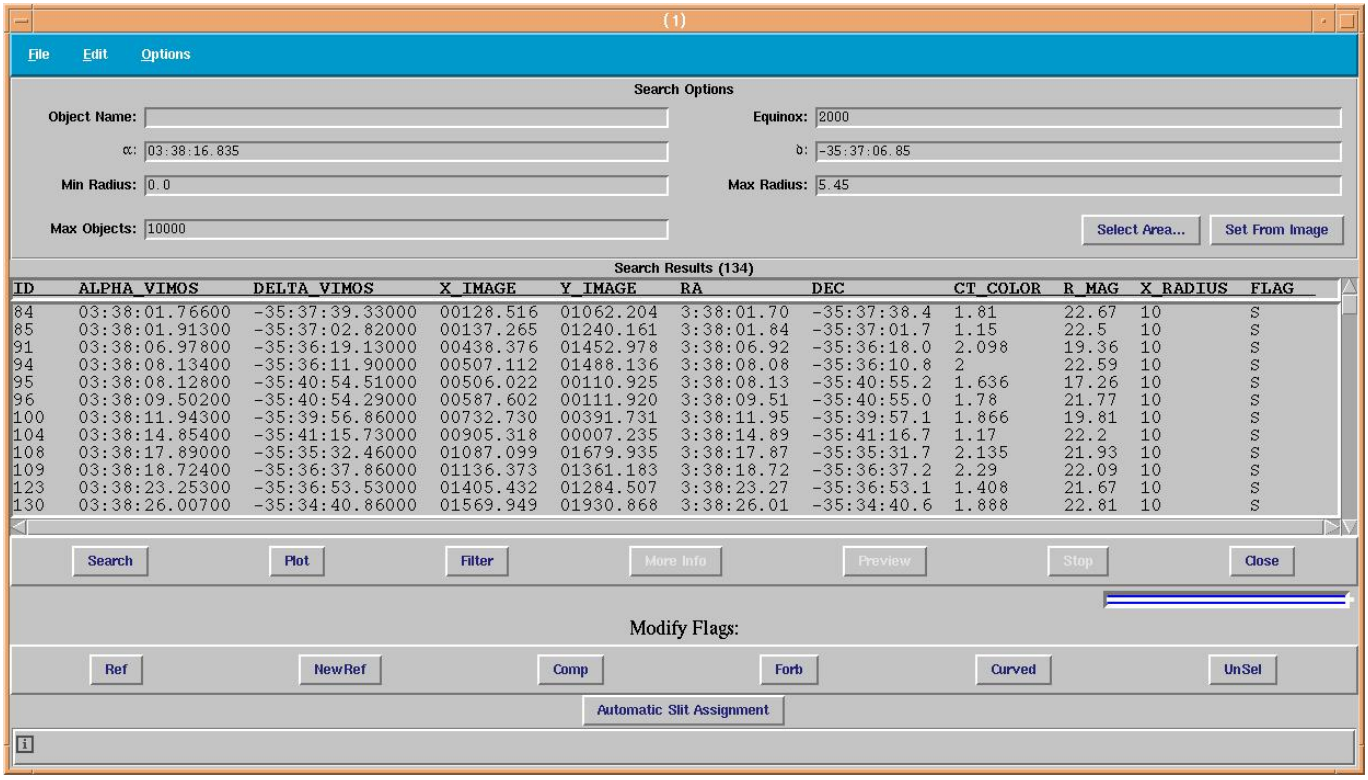
You will be asked to select your VIMOS catalog and the associated VIMOS pre-image. The latter will appear in the display and all objects in your catalog will be marked as white circles. The VIMOS catalog will be shown in a separate window[5].

Your screen will look like this:



[5]There are reports of a possible bug loading the image in some circumstances. See Section 6.3.

Let's focus on the catalog window. We dragged it a little wider to see all columns. That window displaying your catalog might look like this:



Your catalog has internally been transformed into `skycat` format and is now displayed with the standard `skycat` catalog window.

This window shows all objects in given radius (5.45 arcmin by default) from the center of your pre-image. The data section in the middle of the window allows you to look at your catalog, check values for given objects, etc. A click on an object in the image display will highlight that object in the catalog an allows you to examine its entries.

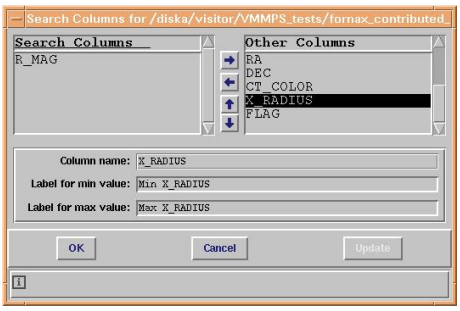
The main purpose of the catalog window is to edit interactively the column 'FLAG', that was added by VMMPS (and set to 'S': select-able for all objects) if not present in your input catalog. How and why to edit this column is explained in Step 5, and uses the lower part of the window ('Modify Flags').

The other purpose of this window is to allow you all operations permitted on skycat catalogs (editing values for selected objects, searching for objects, etc). We do not expect you to need these and therefore recommend to you not to use, mis-use or ab-use of them. Except maybe for an object selection explained in Step 4, but this is optional. If you are satisfied with what you see, move directly to Step 5.

6.2.5 Step 4 (optional): Re-arranging your `VIMOS catalog`

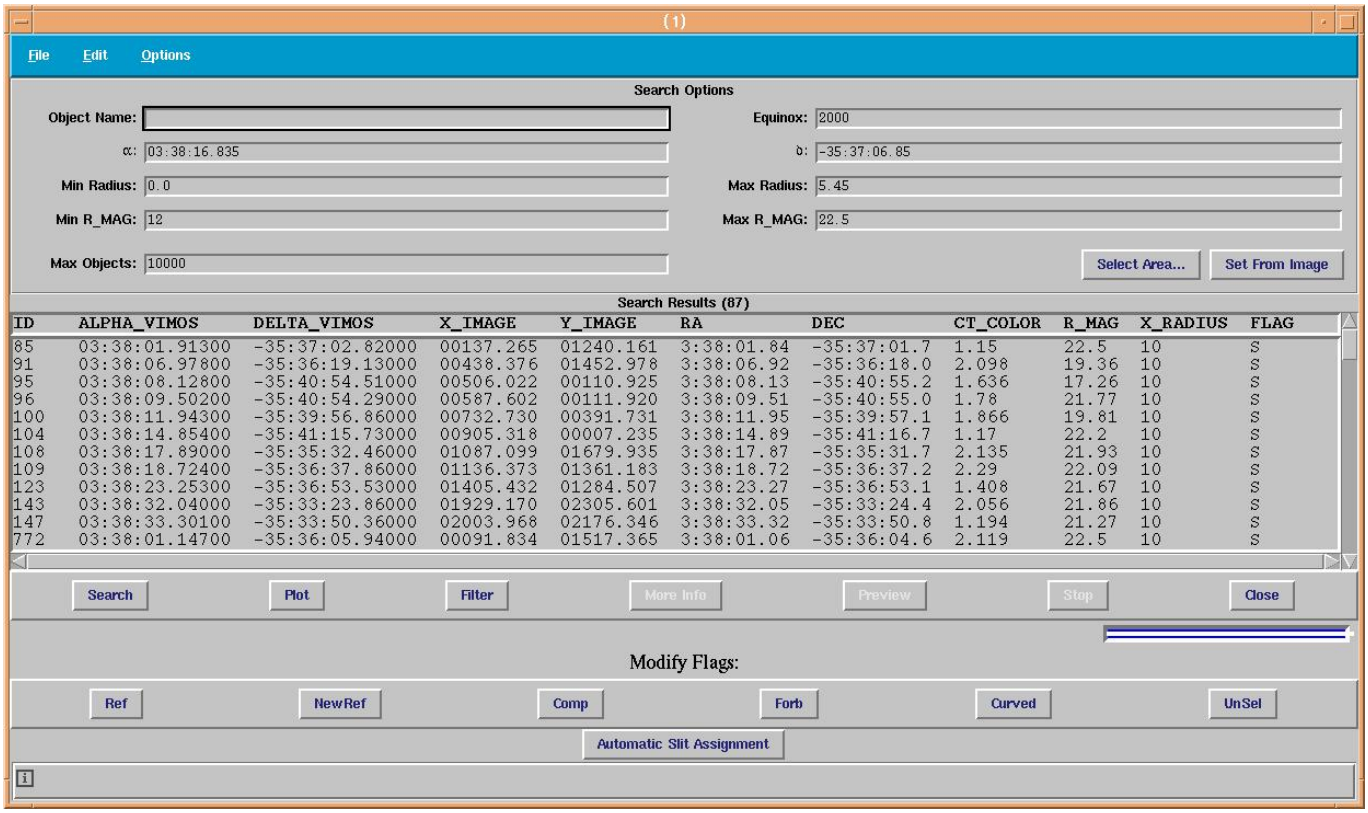
This step is optional. You can skip it and move directly to Step 5.

In case you are not fully satisfied with all objects in your catalog, you have the chance to re-arrange it somewhat. To do so, you must have the column(s) on which you want to constrain your objects in the catalog, and you must have made up your mind which range you want to allow for this columns. If this is fulfilled, go in the catalog window to the pull-down menu 'Options' and select 'Set Search Columns...'. The following window will pop-up:



At this point, you should chose the column(s) on which you want to select your catalog. Click on the column name in the right sub-panel, then click on the left arrow in the central bar: the selected column name(s) should appear in the left sub-panel. Ignore the lower part of that window, you can use it for indicative purposes, but you are not expected to fill in any values at this point.

Once all the columns you wish to select on are in the left sub-panel, click 'OK'. The pop-up window will disappear, and your catalog window will get updated as shown in the example below:



Here we have chosen to select according to the R magnitude (say we changed our mind and decided to allow slits only for objects brighter than 22.5, despite the fact that our VIMOS catalog contains objects down

to $R \sim 24$).

Notice the two new fields in the upper part of the window saying “Min R_MAG” and “Max R_MAG”. Enter there the values on which you want to select the catalog and hit return, or click on ‘Search’ below the data field.

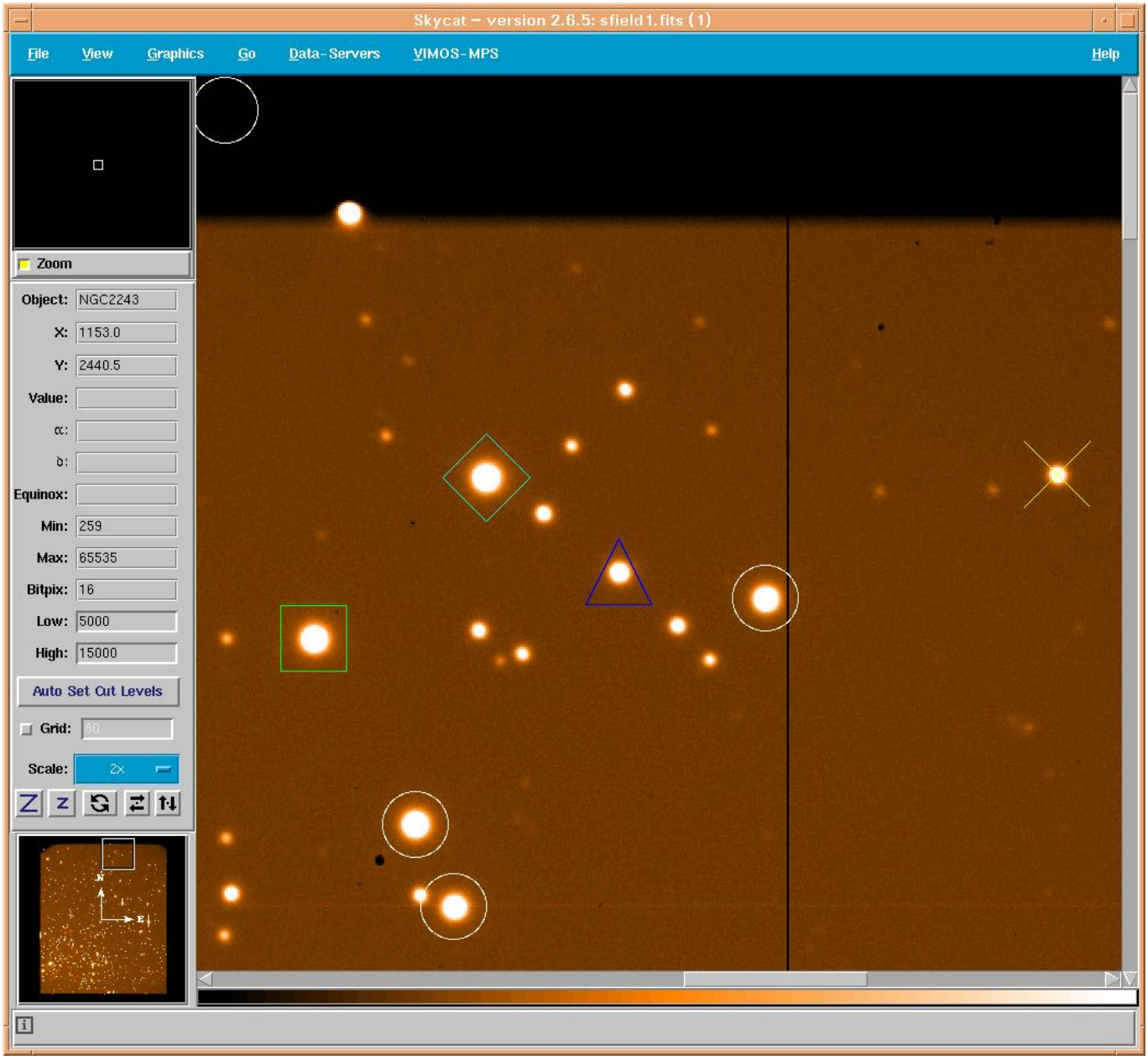
The catalog display will be updated, as well as the overlay on the image. They will now show only objects fulfilling the new selection criteria. And only these objects will be used for assigning slits in the next step.

6.2.6 Step 5: First pass – defining special objects

Alright, if you made it to here, you are ready to assign some slits to some objects. You are doing well so far. In VMMPS, you will first assign all special objects before the rest of the space will be filled automatically with objects. We have 5 types of special objects:

- reference objects (cyan diamonds)
- new reference objects (cyan diamonds)
- compulsory objects (blue triangles)
- forbidden objects (yellow crosses)
- curved slits (green squares)

They are all illustrated in the example below.



The way to assign one of these is the same for all types:

- in the image display, click on the object you want to assign a special type. That object must be in the catalog, i.e. have a white circle around it (exception: new reference objects). The white circle will be highlighted
- in the catalog window, under "Modify Flags", click on the button corresponding to the type you want to assign to the object (e.g. you just clicked in the image on a object that you want to be a reference, so click now on the button 'Ref') – curved slit is a special case described in more details below
- in the catalog window, the object will be highlighted. You can check whether in the column 'FLAG' the type was changed from S (select-able) to the new type (e.g. R for reference)
- repeat the above steps as often as you need

After this operation, you will have updated the 'FLAG' column in you catalog. You are ready to pass to Step 6. Be reminded that at this point all objects with X_RADIUS > 45 pix will be flagged as forbidden.

Note that instead of doing this interactively inside VMMPS, you could have created earlier in the input catalog the column 'FLAG' and assigned the right types (except for curved slits) to the objects.

E.g. if you knew in advance which ones would be your reference objects, you could have created a column 'FLAG' in the input catalog and set it to 'R' for these objects, 'S' for all others.

Once you launch the automatic slit assignment (Step 6), the task will allocate the slits in the above order of priority, i.e. first put boxes around the reference objects, then try to fit all compulsory objects, then try to fit all curved slits, and than finally assign 'normal' slits as many other objects as possible (the latter is described in Step 6).

But first, let's have a closer look at each type of special objects.

Reference objects

Reference targets should be stellar and typically have R 15-18. The acquisition exposure time should be checked assuming imaging mode with the VIMOS ETC, requiring high S/N (50-100). It is important to check that they **do not saturate in good conditions (seeing $\approx$0.5″).** The spectra of these objects are sometime the only spectra available to estimate the image quality. If reference targets are fainter (which is allowed), longer acquisition time will be necessary, thus limiting the available science time.

When selected, the reference objects gets its FLAG parameter set to 'R'. These objects are put by the software in each mask produced for that quadrant before any other object gets allocated a slit. The reference objects are assigned a 4"$\times$4" box.

Remember that in VIMOS the masks of the 4 quadrant are absolutely stiff with respect to each other. Thus, in theory, it would be enough to have 1 reference object per quadrant, or even only 1 quadrant with reference objects. **The software only checks for 1 reference object in your catalog and lets you get away with it. However, we recommend to allocate 3 to 4 reference objects per quadrant in a triangular pattern.** With some experience, you will also 'put them out of the way' of slits or slit rows (e.g. in a triangular pattern away from the field center but avoiding the field corners and edges where optical distortions can be large). These reference stars will allow you or the astronomer on duty to verify that indeed no single mask is tilted with respect to the three other ones. Make sure that these reference objects are centered in their respective boxes as the acquisition software will use the position of these objects for a first estimate of the offset needed to be

applied to the telescope to center the mask.

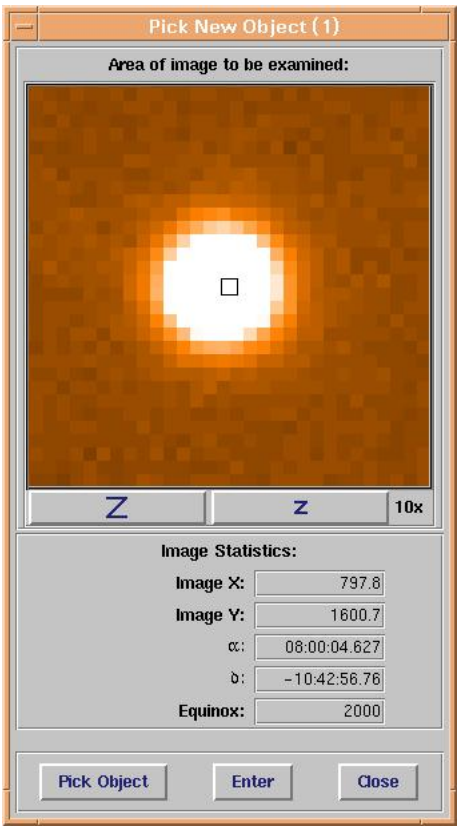
If you intend to observe very faint objects which will only become visible after the combination of many exposures then assign a few slits per quadrant to brighter objects which will serve as a sanity check for the observer. The presence of those objects in the resulting spectral frame will indicate that indeed everything went fine with the observations.

New reference objects

It can happen, that no object in your catalog is suited as reference star. In that case, you can add reference stars directly from the image. This should not be the default mode, since the centering algorithm used by `skycat` is a simple Gaussian fit and might not return as accurate coordinates as your favorite source detection program. The whole alignment procedure on sky might become less precise than with a well prepared catalog including reference stars on the same system as your scientific targets.

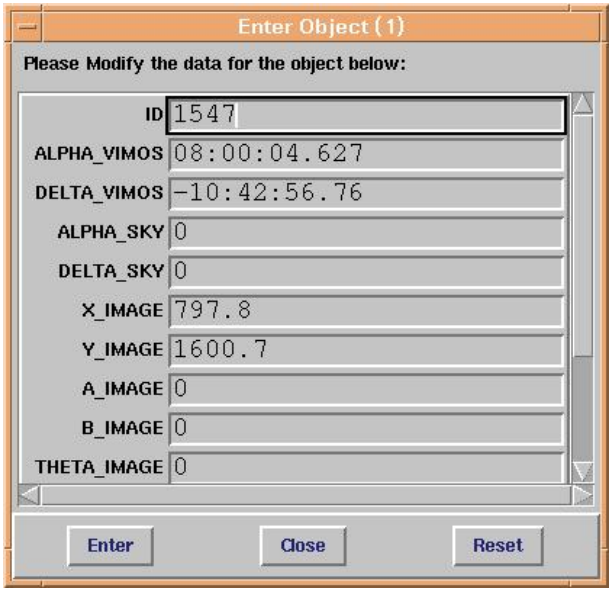
The procedure to pick new reference stars is a little different than the one described above, since obviously you cannot click on a highlighted object in the image display.

In order to select new reference stars, just click on the button 'New Ref'. This will pop-up a 'Pick New Object' window (see below). Move the cursor in the image display onto the object you want to select and click. Then select 'ENTER' in the panel below, to enter the object in the catalog.



You will be asked to confirm the ID for this object (taken as the highest current ID+1):

And you have the opportunity to change from the default values all other entries for all columns:



The new object appears at the bottom of your object list in the catalog window.

Note that the task is called ‘New Ref’ because this is the only case we consider useful, but in principle, once the object is in the catalog, you could change its flag to any allowed value.

Compulsory objects

You can flag a few objects as being the top priority. These objects will be allocated slits immediately after reference objects have been defined on the mask, i.e. VMMPS will make sure that they get slits allocated if not blocked by a reference object. If two compulsory object block each other, VMMPS will allocate one in this mask and the other in the next mask of the series (if applicable).

To flag an object as compulsory, select the button ‘Comp’ after having clicked on the object in the image display. The ‘FLAG’ of the object will be set to ‘C’ (Compulsory) in the catalog.

If you added a column ‘FLAG’ in your input catalog, this flag can be used to set high priorities.

Sometimes a large number of ”C” compulsory targets in the input catalogue results in crashing VMMPS during slit assignment. See Sec. 6.3.2 for details.

Forbidden objects

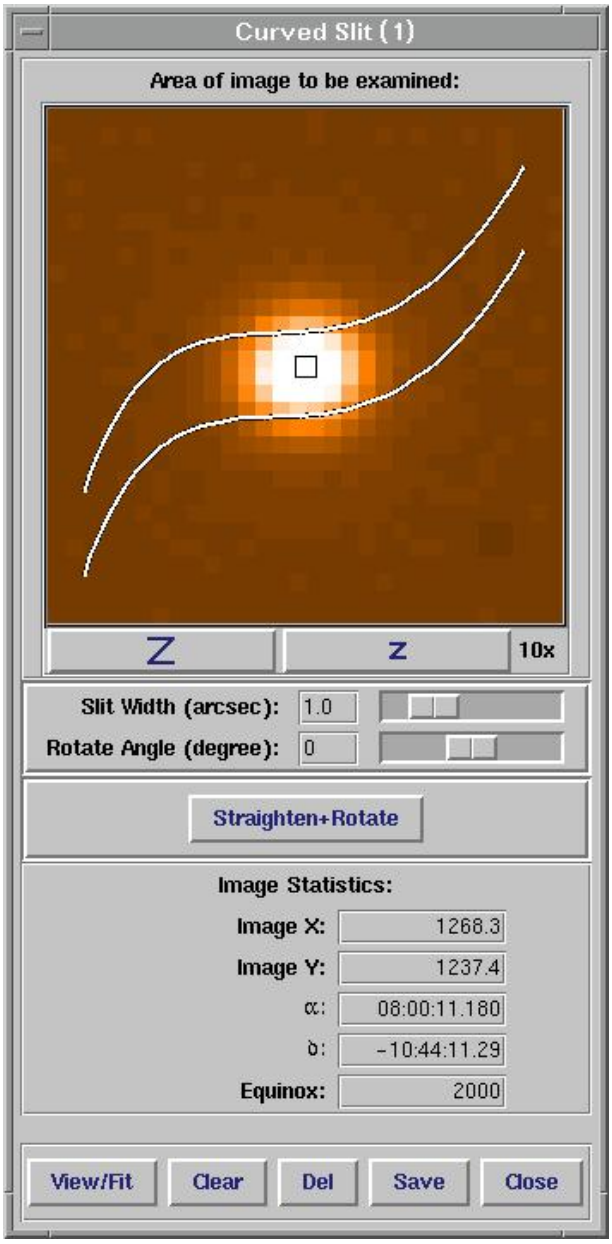
You can exclude individual objects from the automatic slit assignment task. To do so, select the button ‘Forb’ after having clicked on the object in the image display.

If the ‘FLAG’ of an object is set of ‘F’ (Forbidden), that object will not be considered for slit assignment. This has the same effect as removing the object from the catalog.

The cases in which you might need this are rare, it application useful when you use the same catalog for different purposes. E.g. imagine that you use a single catalog to prepare masks for two different grisms and that you have a few objects for which blue spectra are useless. These objects could be flagged manually forbidden when preparing the masks for the blue grisms and save you the time to duplicate the catalog.

Curved slits

You have the possibility to define curved or tilted slits. To do so, click on the button ‘Curved’. This will pop-up the ‘Curved Slit’ window (essentially a Pick Object skycat window with several special features):

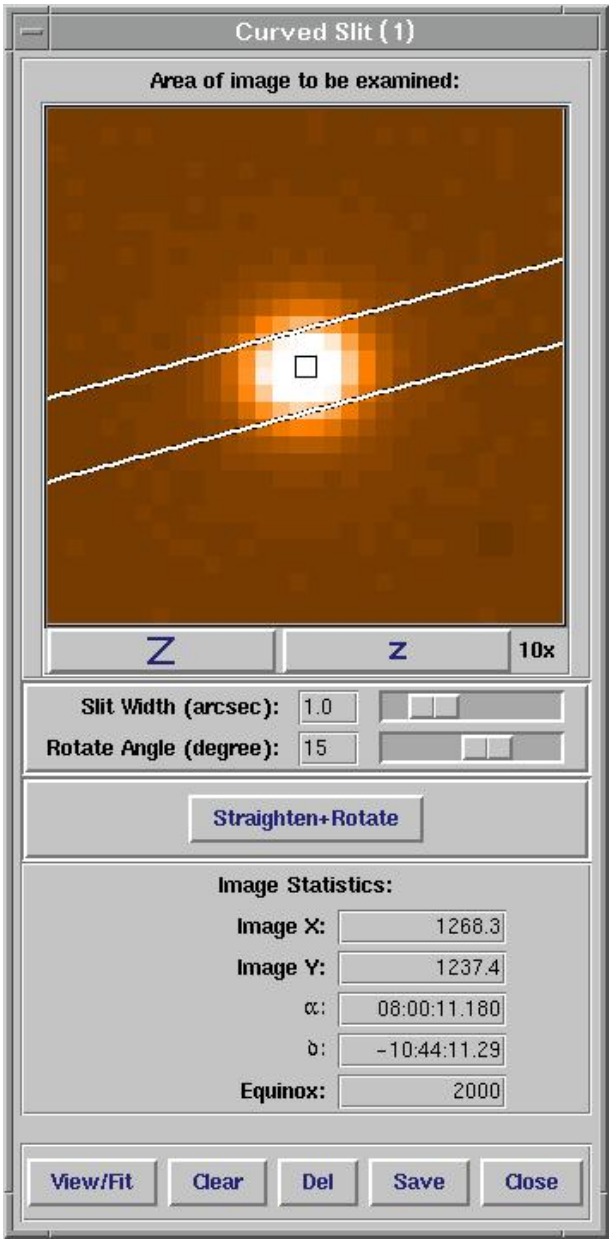


Once you clicked on the object in the image, it appears in the ‘Curved Slit’ window and you can define the curved slit. To do this, click in the little display to define the points through which the curved slit should pass

(start with a point centered on your object maybe). Once you have defined a few points, click on ‘View/Fit’ and the slit will appear.

Note that at any given x, the Δy is kept constant to warranty constant slit width / dispersion along the slit. You can modify the slit width by using the slit width bar (or type in directly the value in the associated box) and click ‘View/Fit’ again.

If you wished a straight slit, just click ‘Straighten+Rotate’ after having clicked ‘View/Fit’. If you wish to give the slit a given position angle, use the ‘Straighten+Rotate Angle’ bar (or type in directly the value in the associated box) and click on ‘Rotate’. Remember that in normal pre-imaging, North is left (-x on detector) and East is up (+y on detector), thus a positive angle here is measured from north (0) to west (+90, which by the way would make very limited sense).



Once you are happy with you curved slit, click ‘Save’. This will update the ‘FLAG’ of the object to ‘A’ and store the fit parameters.

Unselecting objects

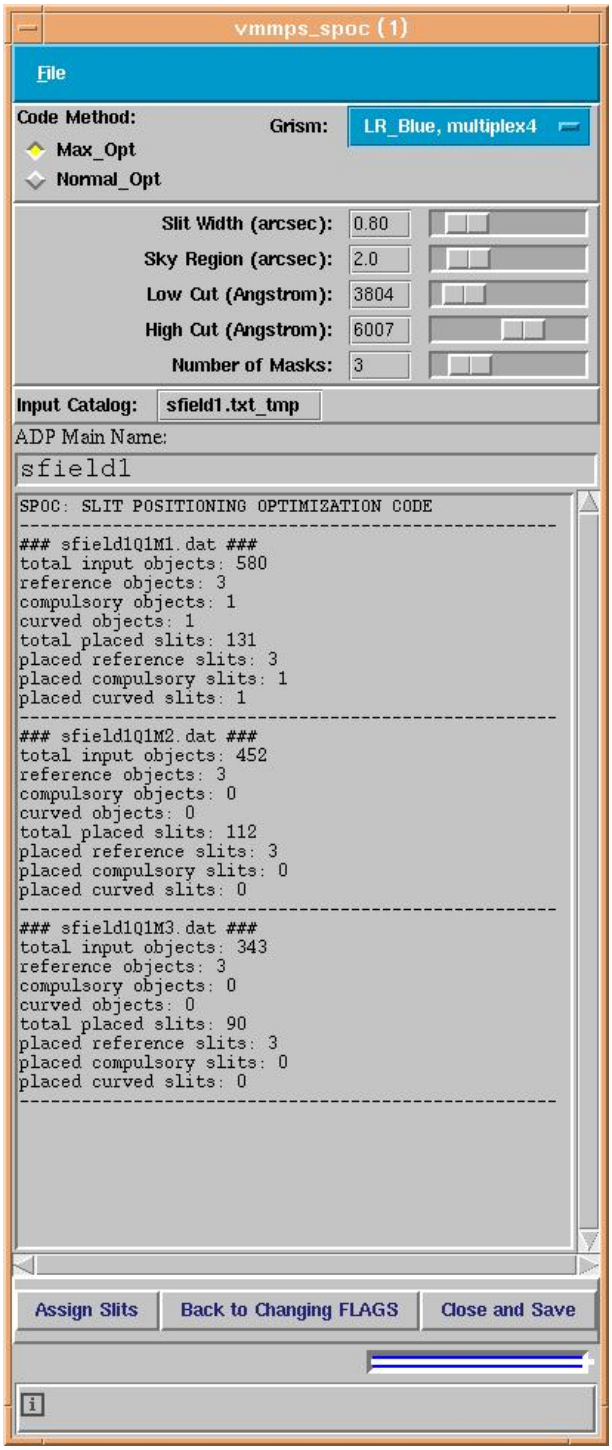
You can, at any time, reset a ‘FLAG’ to ‘S’ (select-able), i.e. erase the special flag you allocated to a object.

To do this: click on a special object then click on the button ‘UNSEL’. If you look now in the catalog, the ‘FLAG’ has been reset to ‘S’.

6.2.7 Step 6: The automatic slit assignment – your first ADP draft

Once you have at least defined a few reference objects, and modified all other flags of your choice in Step 5, you can let VMMPS assign all the slit automatically (the relaxing part).

Select in the catalog window, at the very bottom, 'Automatic Slit Assignment'. This will open the following pop-up window (with the central sub-panel empty to start with):



Here you should define several parameters:

- **The Code Method**: Maximum or Normal Optimization (yeah, you think maximum is always best but wait). The Maximum optimization mode is more efficient in terms of number of placed slits, but favors the smallest (X_RADIUS) objects. The Normal Optimization is less efficient in terms of number of slits ($\sim$ 10% less) but does not bias against large objects. If you have only point source, go for Maximum. If you have extended objects, you might want to use the Normal optimization to avoid biases in your survey.

- **The Grism**: the task needs to know the Grism for two reason. First, in order to define correctly the wavelength range; second in order to define the multiplexity (LR grism allow up to 4 slits in dispersion direction, the MR grism up to 2). The selection of the grism will automatically set-up the minimum and maximum wavelengths in the widgets below, such that your spectra have the maximum length on the detector around the zero-deviation wavelength of the grism.

- **The slit width (arcsec)**: this will define the slit width for all objects (except for reference objects defined by a fixed 4" box and curved slits for which you have defined the slit width separately).

- **Sky Region (arcsec)**: defines the *minimum* sky region that VMMPS will allocated on each side of your object in the slit. The pipeline requires at least 1.8 arcsec. More will reduce the number of position-able slits, but increase your sky subtraction capabilities later.

- **Low / High Cut (Å)**: define the wavelength range that you need, i.e. the common length of the spectra. As mentioned under 'Grism' the value set are giving you the maximum spectral length ($\sim$500 pixels in LR mode, $\sim$2000 pix in MR mode, $\sim$4000 pix in HR mode), centered around the zero-deviation wavelength of the grism. The software will guarantee that length for all spectra. On the other hand, this will constrain the physical region on the mask in which it can place slits. E.g. if you pick the full range in HR mode, only sources in a narrow band in the middle of the detector will be picked. It is thus a good idea to reduce the range to the strict minimum you need. This will allow to select more objects.

- **The Number of Masks**: you can produce one or more masks for a given field. If more than one mask is selected, the reference objects will be placed in *all* masks, the other special objects allocated in order of priority. The task will fill the first masks with slits, then the second with objects that have not been allocated yet and so forth.

- **The Main Name of your ADP**: this name will be extended by the quadrant number, the mask number and the grism name when your ADP files get written on disk.

Once you have set up all the above parameters, you can 'Assign Slits' at the bottom of the window. This will produce a log, shown in the middle sub-panel, telling you how many select-able stars were found in the catalog, the number of special objects, the total of different placed slits[6].

If you are satisfied with the results, click 'Close and Save' and move on to Step 7.

If you wish to change parameters again, just do so and run 'Assign Slits' again. If you think that you screwed something fundamental up (hey, you really forgot reference objects?) then go back to Step 5 by clicking 'Back to Changing FLAGS'.

• **Dirty Trick**: with that title, it will be the most read section of the cookbook, but beware!

If you are interested in a redder or bluer spectral region than offered by default by the software, you can, instead of using the widget bar in 'Low/High Cut', type in numbers directly in the boxes. If this results in a larger range than offered by default, the software will not be able to allocate any slit. However, if you are, say, only interested in the very blue part of the spectra, you could type in e.g. lower cut 3700 Å and upper cut 4500

[6]Sometimes the algorithm fails with an ungraceful core dump. See Section 6.3.

Å. The software will then place the slits in a band at the top of the detector (dispersion direction is y, with red at top) and this will make sure that the full blue end of all spectra lands on the detector [7].

A word of caution: the values you type in here will only constrain the positioning of the slits by the software, but of course, they will not influence the physical length of the spectrae (for that you would need new blocking filters). Thus, in case of multiplexity in the dispersion direction, handle these parameters with care in order to avoid contamination along the dispersion direction.

If you have no clue of what this is all about, you should probably not try the dirty trick.

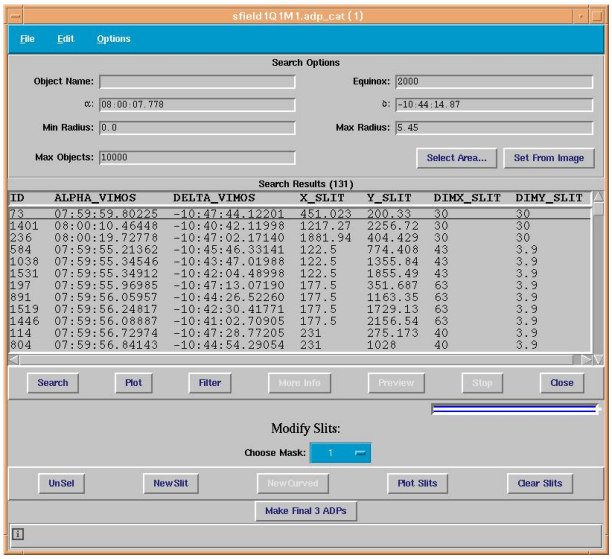
[7] The VIMOS instrument web pages give a good overview of the wavelength range you can expect for each grism as a function of the slit position on the mask. For details see
http://www.eso.org/sci/facilities/paranal/instruments/vimos/inst/mos.html

6.2.8 Step 7 (optional): Fine tuning / last corrections

This step is optional. You can skip it and move directly to Step 8.

The end of Step 6 triggers your old catalog window to disappear and a new one to appear, as well as the display to be updated.

The new catalog window looks as below, and is composed of as many virtual layers as you defined masks for this quadrant. You can step from window to window under 'Modify Slits:', 'Choose Mask' and use the pull-down widget that also indicates on which mask you are currently working.



At this point your ADP has been written, and you could proceed without changes to Step 8. Optionally, if you have the feeling that you should modify a few slits, proceed with this Step but be careful (you are about to try to optimize an optimization).

The window lists all objects that have been allocated slits in this mask. You can now do the final (careful!) fine tuning by unselecting some slits ('Unsel') and/or adding some slits ('New Slit'), following the procedure that should start to be familiar to you by now, interacting with the display (finish by pressing 'Enter' in the Pick-Object window). The new slit will be created with default values: the slit width will be the one that you defined in Step 6 during the automatic slit assignment; the slit length defined by the X_RADIUS of the new object added to the minimum sky region defined in Step 6. Note that in low resolution slits that overlap in dispersion direction get common slit width in Step 6 (to facilitate sky subtraction with second order contamination), *but this is not automatically done here*. Also, there is no check for slit overlap, so be extremely careful.

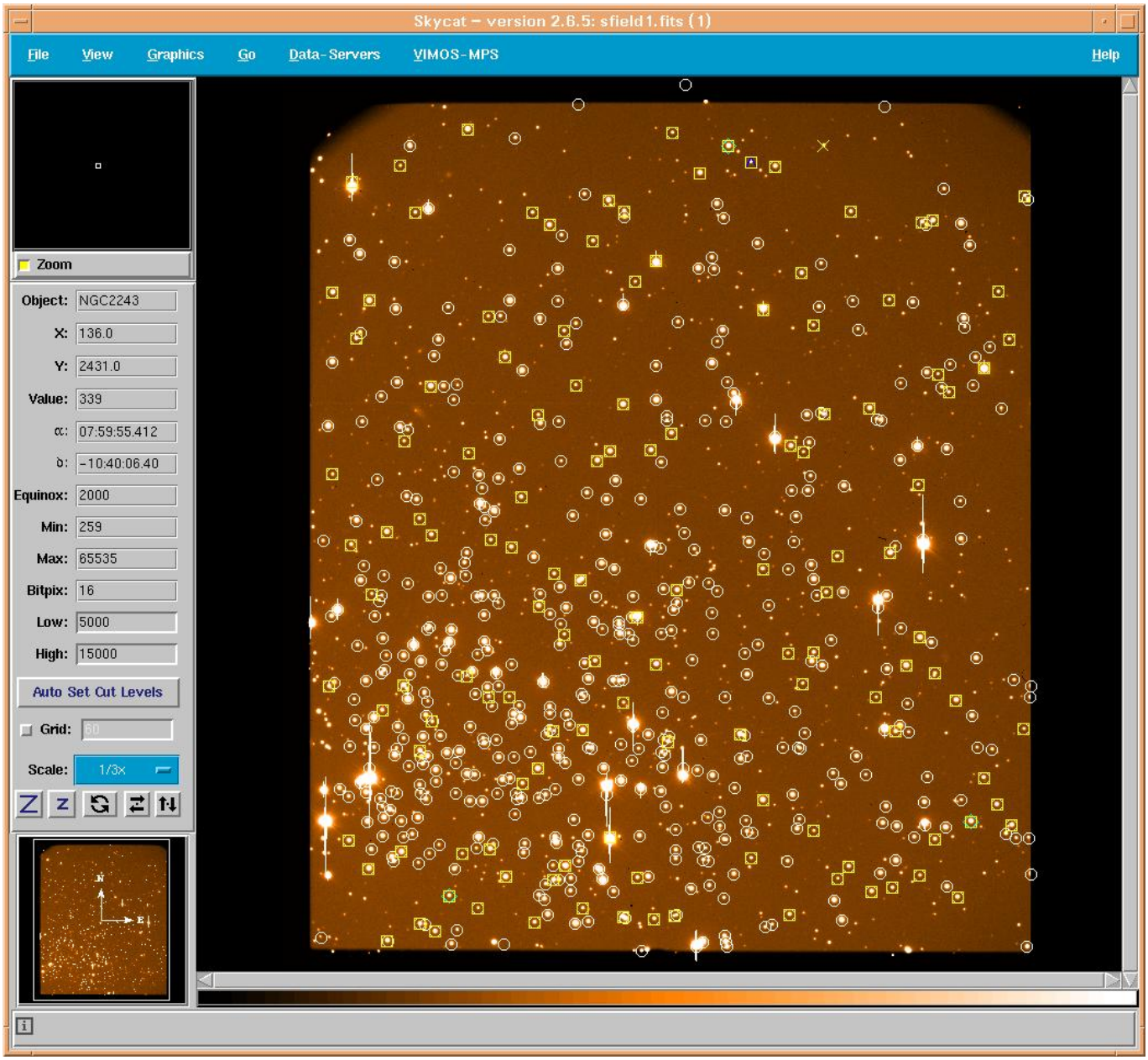
You can edit/modify the values for the new object. A new row with that object will appear at the end of the catalog in main catalog window and the entries for this object can be modified by you. To do this, click on the row with the new object (that gets highlighted then) and go to the pull-down menu 'Edit' to choose 'Edit selected object...'. This opens a window that allows you to change any entry for that object – typically you want to change only the values of DIMX_SLIT (slit length) and DIMY_SLIT (slit width). For science targets you should keep DIMY_SLIT below $4''$ as wider slits will probably result in saturated screen flat calibrations (to use wider slits you will need a special waiver). If in doubt, use the values of the other objects in the catalog as reference. Once you are done, click on 'Enter', verify that the values have been updated in the catalog, and click on 'Close'. A good practice is then to 'Plot Slits' and visually inspect whether your new slit has the right length (i.e. dimension in x) or whether it is overlapping/touching other slits. Remember to be generous with

space between slits, as you have to respect some physical mask stability criteria.

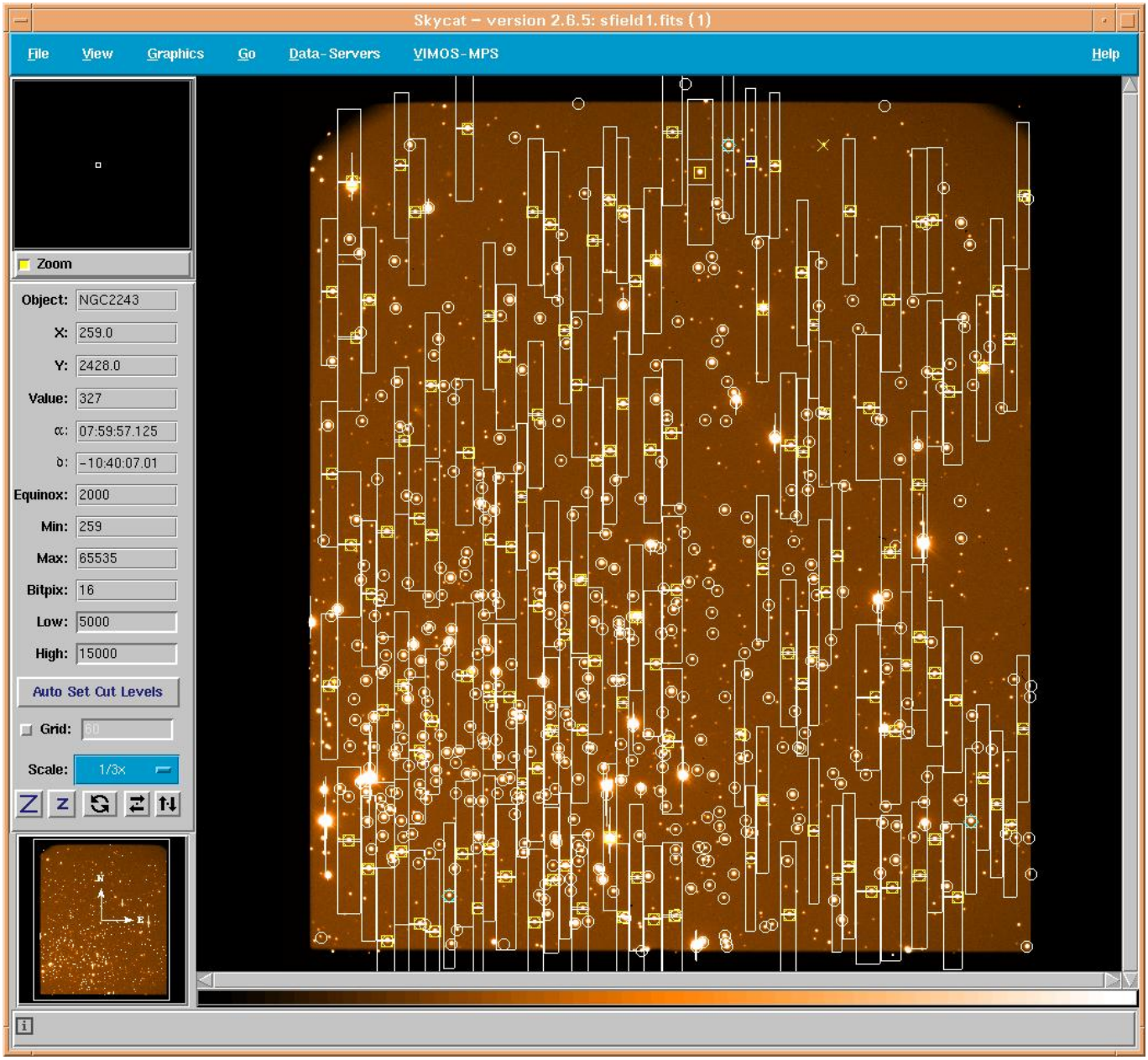
We caution again from doing to many modifications at this point (none should be necessary!) since it is much easier to screw things up here than to improve them. Remember that the task already optimized the allocation. If you modify anything, be sure that you are still respecting all constraints (including contamination issues along the dispersion direction, calibration issues, pipeline requirements, ...). If you have any doubts, do not modify anything, that mask is certainly good enough already.

The software **will not** check whether your new slits are overlapping in the spatial or spectral direction with already allocated ones.

The display now shows all objects in your input catalog marked with white circles, and the objects for which slits were allocated in this mask with yellow squares (special objects are not marked any longer as such).



You can use the button ‘Plot Slits’ and ‘Clear Slits’ to overlay the actual slits and expected spectral range.

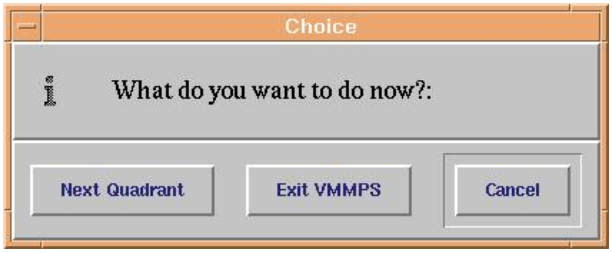


Once you have made the last modifications you can move on to the next mask of the series as described above (‘Choose Mask’), and once you are through with all masks, proceed to Step 8. You are almost there...

6.2.9 Step 8: Writing your final ADP – you have succeeded

Once you are happy with all slits in all masks for this quadrant, click on ‘Make final X ADPs’ where X indicates the number of masks you have defined and for which ADP files will be written.

A last pop-up window will appear:



and ask you whether you want to restart a VMMPS pass e.g. with the next quadrant; exit VMMPS after saving all results; go back to Step 7 (you forgot something...).

Depending on your choice, you will go back to Step 1, go have a coffee or go back to Step 7, respectively. In the first two cases, you will have created ADP files ready to be attached to OBs.

CONGRATULATIONS!

IMPORTANT: note that an APD file edited “by hand” (e.g., changing the slit width with a text editor) will **not** be accepted by p2pp. Based on the slitlets position and size, a checksum parameter is calculated when you create the ADP files, and verified again when the ADP file is attached to an OB. If an inconsistency is found, the ADP file will not be accepted by p2pp.

6.2.10 Loading/verifying previously defined mask

A simple way to come check the ADP your produced is offered in the 'VMMPS' pull-down menu (3rd item): 'Verify ADP file'.

By selecting this task, you will be asked for an input ADP file and the corresponding pre-image. Similar to the slit assignment task, it will display the pre-image and open a catalog window, this time containing only the objects allocated in that given Mask.

You can then as in Step 7 overlay/clear the slits with the buttons 'Plot Slits' and 'Clear Slits'.

Under no circumstances edit the ADP file by hand[8].

[8] ADP file that has been once saved cannot be later modified.

6.3 Troubleshooting and known problems.

Here are some 'features' that we have encountered for you. We are grateful for anyone sending us more 'features'. Remember that an expert is the one who has already made all mistakes himself, you can save some time by using this list in case of problems...

We only assume that you have install the software properly. Especially checked whether your command `skycat` points indeed to the right version, that your environment variables have been set correctly, the right Tcl/Tk libraries are being used,etc. Since these have been our main sources of frustration when we debugged the software. These will typically have the effect of not opening some windows, not showing the plug-in in skycat, etc.

OK, so let's assume that you have used your particular version of VMMPS successfully in the past, but now you are in trouble with that particular $#%@#!! set of catalogs/images.

6.3.1 Cross-correlation task

- Process crashes during cross correlation. Check that the number of stars with CROSS=1 is below 500.
- The circles surrounding the objects used and discarded during the cross-correlation are not properly displayed in the image. See section 6.2.3. This does not mean that the cross-correlation went wrong, you need to go to step 3 to visualize further the results of the transformation of your `contributed` catalog.
- You have run the cross-correlation but not objects were found in common (Bummer!).
  Check if:
  – your input catalogs have all the mandatory columns
  – there is an overlap of objects between your `contributed` and your `VIMOS pre-image catalog`
  – you have up-loaded the right pre-image, which is used to make the link between `contributed` and `VIMOS pre-image catalog` coordinates.
- Your final transformation gives RMS$>$ 1" (hmmm....)
  – are you sure that your contributed catalog has a good astrometry? Especially that it does not suffer from any distortions? Also, check that your pre-image catalog does not contain many spurious detections around the edges of the images. This may confuse the cross-correlation software.

6.3.2 Automatic slit assignment

- VMMPS currently does not check for the presence of reference objects (see section 6.2.6). It is required that at least one reference object is defined per ADP file, and your OBs will be rejected by the User Support Department if this is not the case.
- You loaded pre-image and catalog, but hardly any (no) object appears in the catalog window or is marked in the display.
  – check in the catalog window the 'Max Radius'. It happened to us that with the columns X_WORLD and Y_WORLD in the catalog, `skycat` decided to pick its own Max Radius, which produced the funniest effect (OK, you are not in a mood of laughing right now, never mind). Try changing by hand the Max Radius to something really big (2700?).
- The classical one: you pressed during step 6 the button 'Assign Slits' but of the gazillion of objects in the catalog, none was assigned a slit.

– you might have been too ambitious in the common wavelength range. Try reducing it.
– check the flags in your catalog (they are not all F for some reason, are they?)

- Curved slits: you picked the object and are now clicking madly in the 'Curved Slit' window to determine the fancy curved slit, but no little dots appear. We have not found out why this happens every now and then, but we know that even if you do not see them, they are there (spooky). Try defining a few (virtual) points and click 'View/Fit' that should work.

- There are occasions in which the subroutine/algorithm used to optimize the slit positioning, SPOC, does not converge. In such cases you will see a core dump message saying 'Child process killed'. It does not only happen if there are too many compulsory ("C") targets but also if there are too many reference ("R") or forbidden ("F") targets. One of the possible reasons is that the number of compulsory ("C") targets is too large. Try to solve this problem by reducing the number of ("C") targets changing the flag from "C" to "S" for a subset of them. If you still have problems please contact ESO's User Support at usd-help@eso.org for a possible workaround.

6.3.3 Problems with checksum in ADP files

- When attaching the ADP file, created with VMMPS, to an OB in P2PP I get the message that the file is corrupt. What does it mean? Answer: The P2PP reports that the file is corrupt due to inconsistent CHECKSUM value. This may happen due to opening the file with some editors which add some invisible characters (e.g. end of line character), or sometimes by transferring files between windows and linux computers (depending on the protocol and encoding used for the transfer). Additionally, recently a bug was identified in the step where VMMPS writes the final ADP file. If the button "Make 1 final ADP" is selected, the pop-up window is displayed asking whether to overwrite and save the resulting file .adp. The users should answer "yes" to this question in order to have the correct CHECKSUM written in the ADP file. However, at this point it is not possible to make any more modifications to the mask design. If the button "Make 1 final ADP file" is selected again and the file saved again the resulting .adp file will have incorrect CHECKSUM saved, even if no modifications are made.

- The ADP file created with VMMPS has empty CHECKSUM, which then results in an error when I try to submit the OBs. Answer: Make an ADP file by following the usual procedure and at the end when your reach the step where the button "Make 1 final ADP" has to be selected, a window is popped-up saying that the file .adp exists and asking whether you want to overwrite it. If you say NO, the adp file will still be there (because it was created before the question was issued) but it has empty checksum value. ADP files with empty checksum are not accepted when submitting OBs. Please make sure that when you create ADP files, you answer YES to the question whether to overwrite the file. However, never do this step twice, because this will write an incorrect CHECKSUM.

6.3.4 ADP files and FITS headers

- The coordinates of MOS targets in the FITS headers make no sense. They are different from those in the VMMPS ADP files. Answer: If, after the automatic slit adjustments, a slit is modified interactively (manually), then the coordinates written in the ADP file are in format: hh:mm:ss.ddd for RA and dd:mm:ss.ddd for DEC. Instead for all slits automatically assigned the coordinates are written in decimal degrees. Then when the FITS header is written the coordinate keywords: HIERARCH ESO INS SLIT7 OBJ RA HIERARCH ESO INS SLIT7 OBJ DEC get truncated just before the first ":" and therefore have incorrect values. This may create problems for some data reduction pipelines (e.g. VIPGI).

6.3.5 Other problems

- There are reports of a possible bug: the image is displayed but a pop-up message appears stating ”ERROR: Fits file VIMOS image”, after which one can not proceed with the cross-correlation. If that happens the user can try to load the image again using the Open sub-menu of the File menu in the skycat main window. If that does not work, please contact ESO’s User Support at usd-help@eso.org.

6.4 Examples of catalogs

6.4.1 A contributed catalog

The following shows an example of a contributed catalog. Note that all mandatory columns (ID, RA, DEC) are in, as well as a couple of optional reserved columns (X_IMAGE,Y_IMAGE), and a few user columns (VI_color, V_MAG). All these will be carried over to the output of the Cross-correlation task (i.e. stored in the resulting VIMOS catalog that will serve as input to VMMPS).

ID	RA	DEC	VI_color	V_MAG
1	3:21:46.54	-37:13:43.9	1.751	23.26
2	3:21:49.01	-37:11:32.2	1.948	23.35
3	3:21:50.53	-37:15:04.7	1.774	23.53
4	3:21:56.17	-37:07:29.6	1.599	23.17
5	3:21:56.27	-37:16:22.5	1.927	23.37
6	3:21:57.11	-37:13:26.3	1.063	23.26
7	3:21:58.51	-37:11:34.0	1.198	23.44
8	3:21:58.65	-37:13:54.4	1.372	22.83
9	3:22:02.05	-37:05:41.3	1.399	23.3
10	3:22:03.02	-37:08:21.6	1.924	22.41
11	3:22:03.31	-37:08:08.7	0.8833	23.15
12	3:22:03.69	-37:11:45.7	0.9918	23.31
13	3:22:03.98	-37:07:01.0	1.462	23.08
14	3:22:04.55	-37:10:33.4	1.101	23.39
15	3:22:05.18	-37:09:13.1	1.393	22.9
16	3:22:06.29	-37:20:40.4	1.095	23.09
17	3:22:08.03	-37:05:37.7	1.592	23.19
18	3:22:08.23	-37:06:39.4	0.9589	22.85
19	3:22:08.47	-37:13:56.4	1.662	22.5
20	3:22:10.81	-37:14:42.0	1.694	23.58
21	3:22:11.01	-37:16:31.6	1.664	23.53
22	3:22:11.92	-37:17:40.3	1.725	23.41
23	3:22:12.28	-37:18:52.5	1.103	23.54
24	3:22:12.39	-37:11:01.7	1.383	22.79
25	3:22:13.73	-37:11:56.5	1.203	23.3
26	3:22:14.66	-37:15:55.2	0.8767	23.32
27	3:22:15.96	-37:13:32.6	1.283	22.39
28	3:22:15.99	-37:10:53.6	1.441	23.32
29	3:22:16.20	-37:15:47.4	1.217	22.99
30	3:22:19.93	-37:17:35.5	1.712	23.24

...

6.4.2 A VIMOS pre-image catalog

The VIMOS pre-image catalog was obtained by running our favorite source detection algorithm on the original VIMOS pre-image processed by the ESO pipeline. The output was just plain x,y detector coordinates, we added manually a unique ID. That list, together with the transformation matrix in the header of the pre-image, will be transformed into ra,dec and cross-correlated with the contributed catalog. This will in turn allow to determine the best transformation from ra,dec of the contributed catalog to x,y in pixel coordinates.

```
    ID     X_IMAGE    Y_IMAGE
     1      76.554    497.854
     2      78.566    258.963
     3     100.714     83.548
     4     445.282     69.524
     5    1589.924     51.424
     6     767.057    126.705
     7    1391.149    121.832
     8     229.290    137.767
     9     800.180    157.851
    10    1010.375    156.611
    11    1351.326    177.466
    12     980.319    184.649
    13     548.496    182.759
    14    1534.235    204.140
    15    1310.024    208.284
    16     823.662    233.845
    17     209.727    220.367
    18     706.188    228.008
    19    1797.688    243.397
    20    1936.794    250.302
    21    1996.330    245.786
    22    1046.128    251.701
    23    1737.622    249.215
    24    2018.013    246.191
    25    1851.735    266.140
...
```

6.4.3 A VIMOS catalog

The following shows an example of a VIMOS catalog.

```
ID X_IMAGE  Y_IMAGE A_IMAGE B_IMAGE THETA_IMAGE    MAG   MAGERR
1   233.036 549.141  66.651  4.305    -89.9      7.4464  0.0001
2   891.844 360.569  53.105  7.911    -87.4      7.9803  0.0002
3   100.238  84.054  60.828 24.763    -10.0     11.2455  0.0053
4   601.006  67.561 428.910  9.910     -0.6      9.9766  0.0027
5  1708.843  51.041 104.712 12.829     -1.9     99.0000 99.0000
6   978.752  48.620  12.126  4.303    -12.4     12.7846  0.0047
7  1209.031  74.048  28.632  6.684     -2.3     10.1976  0.0008
8  1212.790  59.548  18.403  5.147     -5.5     10.3681  0.0007
9  1127.769  61.476  21.994  6.201    -89.3      8.5845  0.0002
10 1146.020  73.446  10.094  8.440    -36.7      9.5569  0.0003
11  797.370 124.978   4.882  3.866    -87.6     10.2443  0.0003
12  456.249  66.226  35.585  7.872      3.8     10.2253  0.0010
13  993.617  51.635  19.266 10.830     16.2     99.0000 99.0000
14 2036.250  59.659  58.085  8.955     -0.7     10.4253  0.0012
15  281.472  76.981  10.187  7.927    -33.5     10.6445  0.0008
16  412.076 102.149   4.210  3.252     89.7     11.2830  0.0006
17  882.229 477.262  35.568  3.459     89.9      8.0405  0.0001
18  179.795  30.820   1.176  0.901      8.0     17.1447  0.0356
19 1205.669  89.548   4.645  2.893      6.0     11.3859  0.0007
20 1527.264 133.530   3.779  3.458    -75.3     10.6818  0.0003
21  871.428 246.348   9.820  4.277     89.1      9.4710  0.0002
22 1458.521 103.164   2.132  2.078    -22.0     13.4509  0.0025
23  370.528 123.550   2.785  2.643    -55.8     11.4401  0.0005
24  472.827 106.763   2.265  2.148    -53.4     12.7780  0.0014
25  934.416 137.586   3.261  2.952     52.2     11.0887  0.0004
26  385.186 121.721   2.487  2.315    -55.9     12.1251  0.0008
27 1317.302 113.621   2.276  2.197     -3.6     12.4142  0.0010
28  926.796 142.882   3.188  2.830     63.5     11.0968  0.0004
29  832.140 129.522   2.786  2.713    -17.4     11.4509  0.0005
30  975.537 113.508   2.163  2.068    -10.8     13.0277  0.0017
...
```

6.4.4 Example of an ADP file

Your final ADP file should look something like this. It starts with a few PAF/INS keywords defining the file itself. In then adds the crucial telescope/pointing parameters, before describing for which instrument configuration the ADP has been created. It then gives the most important part: the CCD to Mask transformation. Only then comes the part describing first the reference objects and then all slits defined for this mask, with all curved slits appearing at the very end (and an example is appended here).

```
PAF.HDR.START
PAF.TYPE "paramfile"
PAF.ID "073.A-0602C+3.18+2004-05-12T15:50:59.001+1"
PAF.NAME "wfi16_vm_LR_Red_M1Q1.adp"
PAF.DESC "ADP: Aperture Definition File in Pixel"
PAF.CRTE.NAME "vmmps-3.22+"
PAF.CRTE.DAYTIM "2004-05-12T15:50:59.001"
PAF.LCHG.NAME ""
PAF.LCHG.DAYTIM ""
PAF.CHCK.NAME ""
PAF.CHCK.DAYTIM ""
PAF.CHCK.CHECKSUM "954768746"
PAF.HDR.END
INSTRUME "VIMOS"
OCS.CON.QUAD "1"
INS.FOCU1.TEMP "12.31496"
INS.ADF.TYPE "MOS"
INS.ADF.VERSION "3.22+"
INS.ADF.UNIT "PIXEL"
INS.ADF.ID "wfi16_vm_LR_Red_M1Q1.adp"
INS.ADF.COMMENT ""
INS.MASK1.ID "-1"
TPL.FILE.DIRNAME "$INS_ROOT/$INS_USER/ADF"
TPL.FILE.KEEP "T"
DATE-OBS "2004-04-20T06:57:05.802"
TEL.GS1.ALPHA "191457.06000"
TEL.GS1.DELTA "-460255.35599"
TEL.GS1.PPOS "NEG"
ADA.POSANG "90"
TEL.TARG.ALPHA "191427.80880"
TEL.TARG.DELTA "-460426.61600"
TEL.TARG.EQUINOX "2000."
TEL.TARG.NAME ""
INS.ADF.GRISM.NAME "LR_Red"
INS.ADF.GRISM.SPECTLEN "640"
INS.ADF.SKYREG "1.8"
INS.REF.NO "1"
INS.ARC.NO "0"
INS.SLIT.NO "46"
INS.SHU.NO "4"
INS.SHU1.POSL "0"
INS.SHU1.POSH "769"
INS.SHU2.POSL "769"
```

```
INS.SHU2.POSH "1549"
INS.SHU3.POSL "1549"
INS.SHU3.POSH "2249"
INS.SHU4.POSL "2249"
INS.SHU4.POSH "2440"
PRO.CCD.MASK.DAYTIM "2004-03-25T19:21:18.334"
PRO.CCD.MASK.TEMP "14.490387"
PRO.CCD.MASK.X0 "-131.872451572"
PRO.CCD.MASK.XX "0.11921553"
PRO.CCD.MASK.XY "-0.00010888833"
PRO.CCD.MASK.X_0_0 "-0.18869123"
PRO.CCD.MASK.X_0_1 "0.00054856849"
PRO.CCD.MASK.X_0_2 "-4.812277e-07"
PRO.CCD.MASK.X_0_3 "1.3219545e-10"
PRO.CCD.MASK.X_1_0 "0.00022477421"
PRO.CCD.MASK.X_1_1 "-5.4715579e-07"
PRO.CCD.MASK.X_1_2 "5.5136728e-10"
PRO.CCD.MASK.X_1_3 "-1.8931227e-13"
PRO.CCD.MASK.X_2_0 "-8.3582309e-08"
PRO.CCD.MASK.X_2_1 "3.428154e-10"
PRO.CCD.MASK.X_2_2 "-4.1386207e-13"
PRO.CCD.MASK.X_2_3 "1.420323e-16"
PRO.CCD.MASK.X_3_0 "-6.977006e-12"
PRO.CCD.MASK.X_3_1 "-5.0065001e-14"
PRO.CCD.MASK.X_3_2 "8.499529799999999e-17"
PRO.CCD.MASK.X_3_3 "-2.9409612e-20"
PRO.CCD.MASK.Y0 "-126.018852108"
PRO.CCD.MASK.YY "0.11921683"
PRO.CCD.MASK.YX "7.9496414e-05"
PRO.CCD.MASK.Y_0_0 "-0.20919197"
PRO.CCD.MASK.Y_0_1 "0.00026838485"
PRO.CCD.MASK.Y_0_2 "-6.4661712e-08"
PRO.CCD.MASK.Y_0_3 "-1.2921672e-11"
PRO.CCD.MASK.Y_1_0 "0.00039152516"
PRO.CCD.MASK.Y_1_1 "-1.644576e-07"
PRO.CCD.MASK.Y_1_2 "-7.9799032e-11"
PRO.CCD.MASK.Y_1_3 "6.9466793e-14"
PRO.CCD.MASK.Y_2_0 "-2.9800619e-07"
PRO.CCD.MASK.Y_2_1 "-4.8490222e-11"
PRO.CCD.MASK.Y_2_2 "1.4704649e-13"
PRO.CCD.MASK.Y_2_3 "-6.7603913e-17"
PRO.CCD.MASK.Y_3_0 "8.9077175e-11"
PRO.CCD.MASK.Y_3_1 "7.827672800000001e-15"
PRO.CCD.MASK.Y_3_2 "-3.7850445e-17"
PRO.CCD.MASK.Y_3_3 "1.8410463e-20"
INS.REF1.TYPE "SQUARE"
INS.REF1.ID "22595"
INS.REF1.OBJ.RA "243.9472351074219"
INS.REF1.OBJ.DEC "-6.144344329833984"
INS.REF1.X "1017.37"
INS.REF1.Y "1153.78"
```

```
INS.REF1.DIMX "30"
INS.REF1.DIMY "30"
INS.SLIT1.TYPE "RECTANGLE"
INS.SLIT1.ID "27467"
INS.SLIT1.OBJ.RA "244.0057983398438"
INS.SLIT1.OBJ.DEC "-6.09309196472168"
INS.SLIT1.X "108"
INS.SLIT1.Y "2175.15"
INS.SLIT1.DIMX "58"
INS.SLIT1.DIMY "4.88"
INS.SLIT2.TYPE "RECTANGLE"
INS.SLIT2.ID "27313"
INS.SLIT2.OBJ.RA "243.9036865234375"
INS.SLIT2.OBJ.DEC "-6.095680713653564"
INS.SLIT2.X "161"
INS.SLIT2.Y "394.478"
INS.SLIT2.DIMX "44"
INS.SLIT2.DIMY "4.88"
INS.SLIT3.TYPE "RECTANGLE"
INS.SLIT3.ID "26930"
INS.SLIT3.OBJ.RA "243.9173889160156"
INS.SLIT3.OBJ.DEC "-6.101338863372803"
INS.SLIT3.X "263"
INS.SLIT3.Y "633.422"
INS.SLIT3.DIMX "38"
INS.SLIT3.DIMY "4.88"
INS.SLIT4.TYPE "RECTANGLE"
INS.SLIT4.ID "26695"
INS.SLIT4.OBJ.RA "243.9308166503906"
INS.SLIT4.OBJ.DEC "-6.104647159576416"
INS.SLIT4.X "312"
INS.SLIT4.Y "867.445"
INS.SLIT4.DIMX "56"
INS.SLIT4.DIMY "4.88"
INS.SLIT5.TYPE "RECTANGLE"
INS.SLIT5.ID "26710"
INS.SLIT5.OBJ.RA "243.9892578125"
INS.SLIT5.OBJ.DEC "-6.10461950302124"
INS.SLIT5.X "312"
INS.SLIT5.Y "1886.62"
INS.SLIT5.DIMX "56"
INS.SLIT5.DIMY "4.88"

....
....

INS.SLIT38.TYPE "CURVE"
INS.SLIT38.ID "1294"
INS.SLIT38.OBJ.RA "54.63366317749023"
INS.SLIT38.OBJ.DEC "-35.58836364746094"
INS.SLIT38.X "1934.2"
```

```
INS.SLIT38.Y "1748.86"
INS.SLIT38.DIMX "72.6812"
INS.SLIT38.DIMY "72.68"
INS.SLIT38.BEZIER.DY "3.41463"
INS.SLIT38.BEZIER.AX "0"
INS.SLIT38.BEZIER.BX "0"
INS.SLIT38.BEZIER.CX "72.6812"
INS.SLIT38.BEZIER.XX "1897.86"
INS.SLIT38.BEZIER.AY "0"
INS.SLIT38.BEZIER.BY "0"
INS.SLIT38.BEZIER.CY "37.0329"
INS.SLIT38.BEZIER.YY "1734.33"

....
....

INS.SLIT46.TYPE "RECTANGLE"
INS.SLIT46.ID "26017"
INS.SLIT46.OBJ.RA "243.9325103759766"
INS.SLIT46.OBJ.DEC "-6.108108043670654"
INS.SLIT46.X "381.9"
INS.SLIT46.Y "897"
INS.SLIT46.DIMX "18.78"
INS.SLIT46.DIMY "9"
```

6.5 User check list

You can use this list to go step by step through the process and tick off each step one by one.

□ **Step 0 (most crucial): Prepare you catalog(s) and image(s)**

You have prepared carefully your catalog(s) and have the corresponding VIMOS pre-images ready. You thought carefully of the objects in your catalog: only objects you do not mind having a slit allocated to them are in there, VIMOS pre-image and contributed catalogs have common objects, you did not modify your VIMOS pre-image, ...

□ **Step 1: Chose the right task to start with**

According to your input catalog you go – to Step 2 if you have a VIMOS pre-image and contributed catalog; to Step 3 if you have a VIMOS catalog

□ **Step 2: From VIMOS pre-image and contributed catalog create a VIMOS catalog**

Skip this step if you have already a `VIMOS catalog`

□ **Step 3: Starting VMMPS for mask definition**

(□ **Step 4 (optional): re-arranging your VIMOS catalog**)

□ **Step 5: First pass – defining special objects**

Have you been careful and defined at least 3 reference objects per quadrant?

□ **Step 6: The automatic slit assignment – your first ADP draft**

Spend some time thinking of your parameters. Tip: select only the wavelength range you really need.

(□ **Step 7 (optional): Fine tuning / last corrections**)

Only go through this step if you are sure to know what you are doing.

□ **Step 8: Writing your final ADP**

And remember never to edit this file by hand. Make finding charts after pressing "Plot Slit" button, by selecting "File->Make Finding Chart" menu.

□ **Step 9: Make finding chart for each quadrant**

For each quadrant the finding chart has to be prepared with VMMPS using the `plotSlit` button and selecting the `File -> Make Finding Chart` option.

YOU ARE DONE!

Chapter 7

PILMOS Tutorial

7.1 Introduction

Until 2011 VIMOS MOS observations have required mandatory pre-image observations to be carried out (usually several months) before the actual MOS exposures in order to ensure accurate positioning of the slits on the MOS masks. This conservative approach was adopted because there are significant technical difficulties involved in accurately predicting slit positions without a pre-image. However recent upgrades to VIMOS have improved its stability and a detailed investigation into the accuracy to which slit positions could be predicted concluded that for many realistic observing programmes it would indeed be a valid approach. As of June 2012 Pre-ImageLess Multi Object Spectroscopy (PILMOS) is being offered as an option to VIMOS users. Currently there are restrictions for MOS observations in PILMOS mode. In addition we encourage users to take note of the expected PILMOS performance as described in [1]. The implementation of the PILMOS option for mask preparation utilises tools and procedures that were already in place for pre-image based mask preparation, consequently section 7.3 describes the procedure with particular emphasis on the new PILMOS specific aspects and directs the reader to existing documentation for the unchanged aspects of the procedure.

7.2 Requirements and Restrictions for PILMOS usage

The initial PILMOS release is subject to conservative restrictions, some of which we expect to relax in future periods. The priority is clearly that the PILMOS option does not lead to slit losses that are greater than would have been experienced via the pre-imaging approach.

7.2.1 Restrictions

In addition to the normal restrictions for MOS/Pre-image, PILMOS observations must abide by the following constraints:

- Slit widths $\geq 1''$.
- No curved or tilted slits.

Observations that cannot be made within these constraints must use the conventional pre-image approach. There is currently no plan to support curved or tilted slits in PILMOS mode.

7.2.2 Catalogue requirements

The catalogue requirements are identical to those currently stipulated in the VMMPS documentation (section 6.2.1 of the VIMOS user manual [1]), namely:

- All objects shall have very good ($<0.2''$) relative astrometric coordinates (RA,DEC) on a single astrometric system. Notice that this constraint differs from the one in sec 6.2.1, as in that section we refer to the relative positioning accuracy within a quadrant, while here we refer to all sources to be observed in all quadrants.

- All objects shall have good ($2''$) absolute astrometry.

In addition, the guide star should be chosen with the Guidecam software (see Chapter 5) and be on the same astrometric system as the contributed catalogue. This may mean applying an offset to the contributed catalogue in order to make it consistent with the guide star catalogue selected in Guidecam.

7.2.3 Other Considerations

PILMOS is not intended to replace completely the conventional pre-image approach; there will be many observations for which PILMOS will not be appropriate. The most obvious is any observation for which a good astrometric catalogue of sources is not available a priori and the pre-image is intended to be used in order to obtain accurate astrometry. The accurate placing of curved or tilted slits on extended sources is also likely to require a pre-image. On the other hand, if you have good astrometry for faint targets, but few good stars for astrometric calibration of the pre-image, PILMOS may be a good option. Moreover, if your observations can be arranged such that targets are not close ($<$200pix) to the detector edges and, in particular, the edges of the total FoV then slit losses will be minimised. Also,if wide slits ($>1.5''$) can be used then there is little to be gained from taking pre-images. The expected performance of PILMOS as compared to conventional pre-imaging is presented in detail in [1]. Users who are concerned about the implications of source centroiding accuracy offered by the two methods should consult that document.

Another consideration is the ratio of the total MOS integration time to the pre-image integration time. Observations where one pre-image can provide masks for multiple MOS follow-ups do not pay much penalty in pre-image integration time and may, in some circumstances, benefit from the extra check of a pre-image. On the other hand, an observation that will consist of just one relatively short MOS follow-up, for which the pre-image is in any case unlikely to reveal faint sources, would be well served by the PILMOS option.

7.2.4 PILMOS features to be aware of

- PILMOS does not work if the reference objects have entries in the ID column that are not integers, and/or if their is another format inconsistency (e.g. in a number of rows some of the fields have merged). It is the user's responsibility to check that their catalogs are properly formatted.

- after starting PILMOS and entering the pointing coordinates into it, no image is displayed and a dialog box pops up with the error message: "Can't find host IP address for: wvgarc" Normally it can be solved by restarting the tool. This is not related to the PILMOS functionality, but rather an issue of the regular Guidecam tool as well.

- if the magnitude column (containing the string 'mag' or 'MAG' as column description) is the last column of the catalog and is the only magnitude column, PILMOS does not display the targets in the 'fake' PILMOS finding charts. However, note that the VIMOS catalogue generation is not affected by this, it is only the simulated fields (which are no more than a crude visual aid anyway) that are affected. (The magnitudes are propagated properly, they just don't get "recognised" as magnitudes and used to scale the flux in the simulated images, instead zero flux is used and the images are empty apart from the guide probe vignette). The work around is to just add another column to the catalaog that is not a magnitude column.

7.3 Preparation of MOS Masks without a Pre-Image

7.3.1 Step 1: PILMOS (Guidecam) Application

The PILMOS application is very similar to the existing Guidecam application described in Chapter 5. The difference is that it includes the possibility of supplying a contributed catalogue from which a VIMOS catalogue and simple simulated pre-image are generated. For pre-imageless observations the PILMOS application should be used instead of the Guidecam application to choose a guide star for your observations, the procedure is however identical to that described in Chapter 5. The only difference is that in order to take advantage of the pre-imageless option, then you will need to supply the filename of your contributed catalogue in the appropriate field of the *Guide Probe Settings* panel and click the "PILMOS button".

The PILMOS application includes instrumental calibration parameters that are continually monitored and will be updated with each release of the application (expected to be once per VLT period). Hence it is essential that you have the latest version of the PILMOS application. A link to the official USD Phase 2 page for downloading the PILMOS tool is available at:
http://www.eso.org/sci/facilities/paranal/instruments/vimos/tools

The tar file includes comprehensive installation instructions.

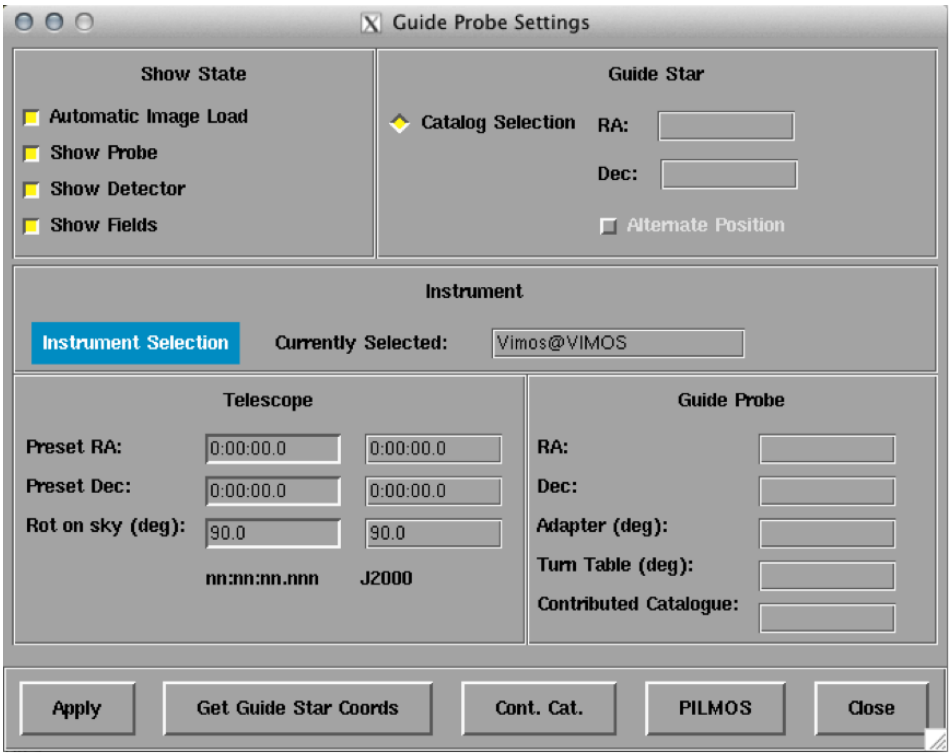


Figure 7.1: Guide Probe Settings window with "Cont. Cat." button (bottom middle) and PILMOS button (bottom, 2nd from right)

Required Input

Figure 7.1 shows the *Guide Probe Settings* interface from the PILMOS application. The required input when setting up PILMOS observations is then:

- **Telescope** (Co-ordinates): Nothing is changed here relative to conventional guidecam/pre-image use. These are the co-ordinates of the centre of the field (located at the point where the four detectors meet):

  - **Preset RA:** HH:MM:SS.sss
  - **Preset Dec:** DD:MM:SS.sss
  - **Rot on sky:** Currently the only allowed orientations are 0°, for -45°$<\delta<$-5°, and 90° for any observable δ. No waivers will be granted for PILMOS observations for any other PA setup.

- **Guide Star Co-ordinates:** Nothing is changed here relative to conventional guidecam/pre-image use. Choose a guide star and its co-ordinates will be reflected in the Guide Star and Guide Probe fields.

- **Guide Probe Orientation:** Nothing is changed here relative to conventional guidecam/pre-image use. By default the guide probe will be set to the NEG position and its silhouette drawn accordingly. Clicking Alternate position will set the probe to the POS position, its silhouette and the Adaptor and Turn Table fields will be updated to reflect this.

- **Cont. Cat. button:** This is a new functionality required for PILMOS observations. This brings up a file system navigation window that should be used to locate the contributed catalogue file. The contributed catalogue should be a text file with the coordinates of spectroscopic targets in exactly the same format as described in Section 6.2.1 of this manual.

- **APPLY button:** This button should be clicked after changes to any of the above fields, including after entry of a contributed catalogue file name, otherwise the file name will not be passed to the PILMOS simulation.

- **PILMOS button:** Pressing this button will send the field and guide probe co-ordinates and the contributed catalogue to the PILMOS simulation.

Finding charts should be prepared as described in Chapter 5.5.

Format of contributed catalogue

The following is reproduced from Chapter 6 except for some exceptional information for PILMOS (emphasized):

The contributed catalogue contains all the objects that you wish to observe. *Note that for PILMOS few bright objects to be used as reference targets for each quadrant need to be included in the contributed catalogue, but there do not need to be many bright targets for cross correlation.* All objects shall have very good ($\pm 0.2''$) relative astrometric coordinates (RA,DEC) on a single astrometric system. Further, all objects should have good ($\pm 2''$) absolute astrometry.

The *mandatory columns* in the contributed catalogue are (in upper case and in the following order):

- **ID** defining an identifier which must be unique and integer number.

- **RA** defining the right ascension of the object.

- **DEC** defining the declination of the object. RA and DEC entries are allowed in 2 formats:
  - decimal degrees
  - hh:mm:ss.s (including semi-colons)

The *optional columns* whose names are reserved are:

- **CROSS** is, for each object, either 1 if that object shall be used for the cross correlations, or 0 if it shall not (e.g. if it is too faint, too elongated, etc.). *Note that this is not relevant for PILMOS.*

- **FLAG** shall be one of (upper or lowercase) C-compulsory; R-reference; F-forbidden; S-selectable (no blank entry is supported, any other flag will be replaced by S). Though not mandatory in the sense that the PILMOS code will not complain if it is not provided, PILMOS users are advised to select reference stars based upon their astrometric source data.
- **A_ARCSEC** the semi-major axis in arcsec
- **B_ARCSEC** the semi-minor axis in arcsec
- **PA** the position angle (E of N in degrees) [These three are not used by the PILMOS code to compute the object size in pixels along the x direction of the detector (i.e. along the slit).]
- Any other columns whose names do not match the above ones.

Notice only that the names X_IMAGE and Y_IMAGE are forbidden in the contributed catalogue—they are used/computed later. If these are present, the software will kindly reject your catalogue until you remove them (well... perhaps not too kindly).

All columns present in the contributed (input) catalogue will be carried over to the output catalogue. Some columns will be used to generate new columns in the output catalogue.

PILMOS Output

The PILMOS application will produce the following output files and write them in the ~/.pilmos directory:

- VIMOS catalogues. One catalogue for each quadrant is created. The catalogues ave the same format as produced by Step 1 of VMMPS, by the cross-correlation of the contributed and VIMOS Pre-image catalogues (see Section 6.2.1). However it will not contain any A_IMAGE, B_IMAGE, THETA_IMAGE or X_RADIUS columns. The filename will be: <*filein*>_<*quad*>_vm.cat where *filein* is the root name of your contributed catalogue and *quad* is the quadrant identifier (B.1, A.2, A.3 or B.4).
- A PILMOS *source chart* for each quadrant. This is a FITS file containing:
  - an image with the targets in the contributed catalogue shown at the appropriate detector co-ordinates, the outline of the guide probe vignette and the fixed vignetting in the detector corners.
  - A header that contains all of the essential keywords that would have been in a pre-image of your field

  This is essentially a simplistic fake pre-image based upon your contributed catalogue with the WCS appropriate for the co-ordinates entered into Guidecam and with an indication of the guide probe vignette for the chosen guide star . The filename will be pilmos_[quad]_sim_[N].fits where quad is the quadrant identifier (B.1, A.2, A.3 or B.4) and N is a counter that allows differentiation between the output of multiple uses of the PILMOS application. These are the files required by Step 3 of VMMPS, *Assign slits from a VIMOS catalogue/produce ADP*, of VMMPS (see Section 6.2.4)

7.3.2 Step 2: VMMPS

If the PILMOS application has been used successfully to generate the files described in Section 7.3, then the Step 2 of VMMPS, *Cross-correlate Contributed and VIMOS Pre-Image catalogues*, which requires measured source centroids from a pre-image, can be skipped. Instead it is possible to go straight to VMMPS Step 3, *Assign slits from a VIMOS catalogue/produce ADP* which can now be executed exactly as described in Section 6.2.4. The PILMOS source chart is essentially a fake pre-image that should be used in this step. Sources will be identified by VMMPS and can be selected for slit allocation in the same way as for a real pre-image. ADPs will be produced as described in subsequent sections of [1] and header information from the PILMOS

source chart will be propagated to the ADPs just as it would have been from a real pre-image.

[1] Bristow. P. et al., PILMOS Implementation and Testing, available from the VIMOS web pages:
http://www.eso.org/sci/facilities/paranal/instruments/vimos/inst/mos.html

[2] VIMOS Pipeline User Manual, VLT-MAN-ESO-19500-3355 Issue 6.2

Appendices

Appendix A

VIMOS Filters

Table A.1 lists the characteristics of the VIMOS filters. The original transmission curves delivered by the consortium are given in the following figures. The zero points and band-pass characteristics valid for the new set of detectors can be found in Section 2.2.4

Table A.1: Characteristics of the VIMOS filters. Updated filter characteristics can be found in http://www.eso.org/sci/facilities/paranal/instruments/vimos/inst/imaging.html

Filter	λ_0 (nm)	FWHM (nm)
U'	370	50
B_BESS	430	97.0
V_BESS	546	89.0
R_BESS	648.5	130.0
I	830	180.0
z_GUNN	950	160
GG475	edge filter	high pass ($>$ 475 nm)
GG435	edge filter	high pass ($>$ 435 nm)
OS-red	box filter	band pass 550-950
OS-blue	box filter	band pass 370-670

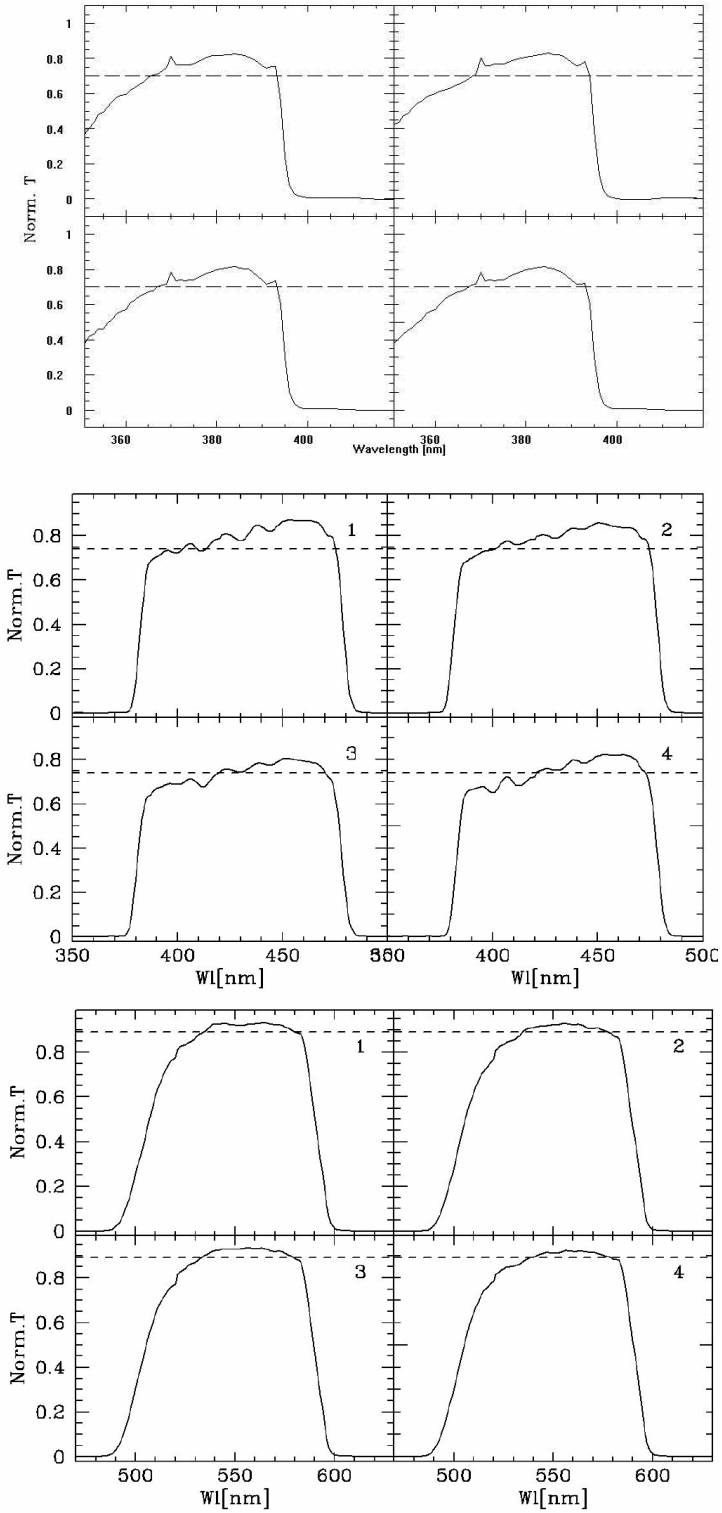


Figure A.1: U',B,V filter transmission curves

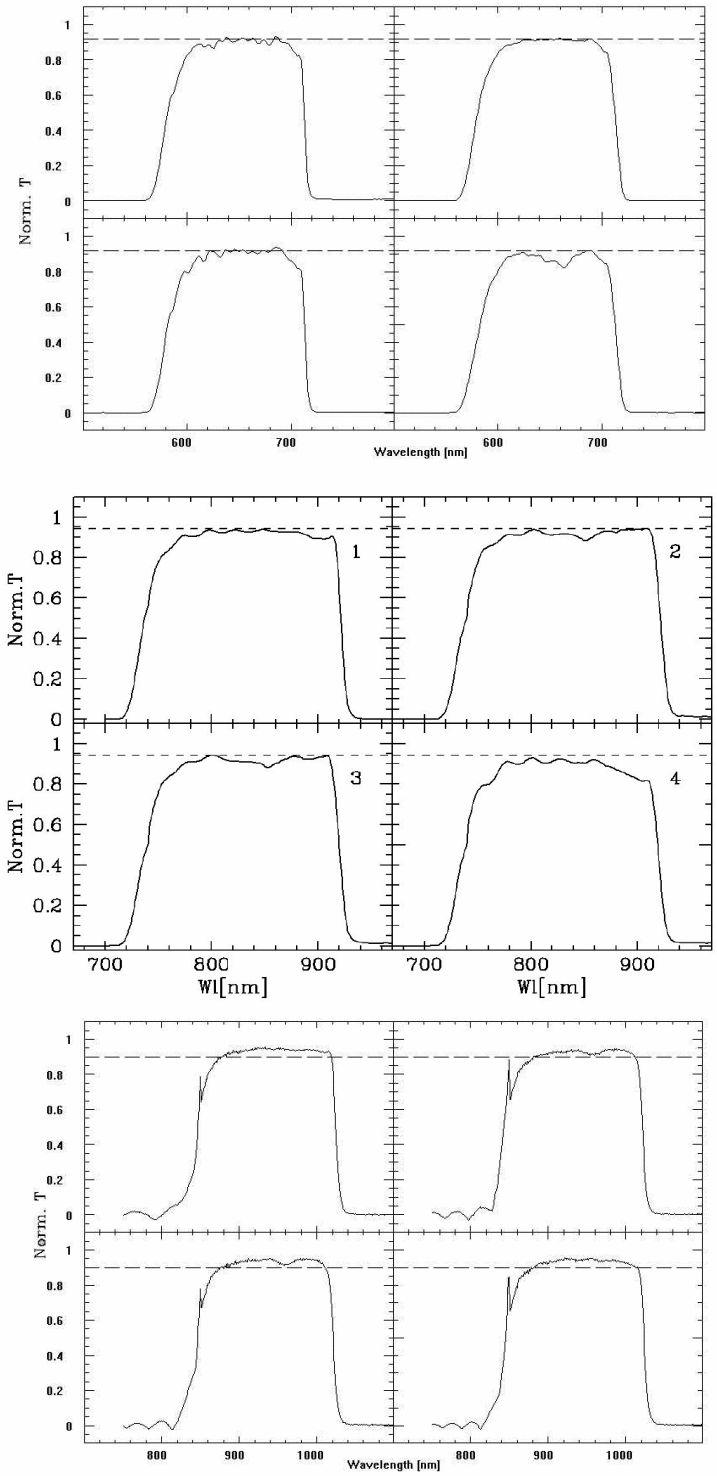


Figure A.2: R,I,z filter transmission curves

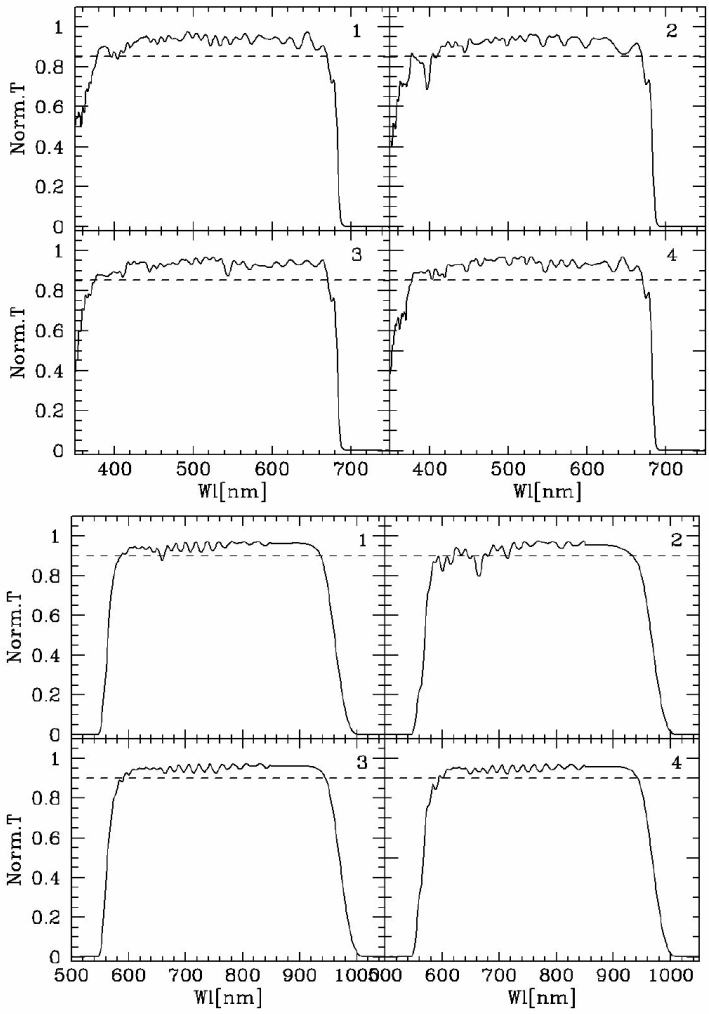


Figure A.3: OS-blue, OS-red transmission curves

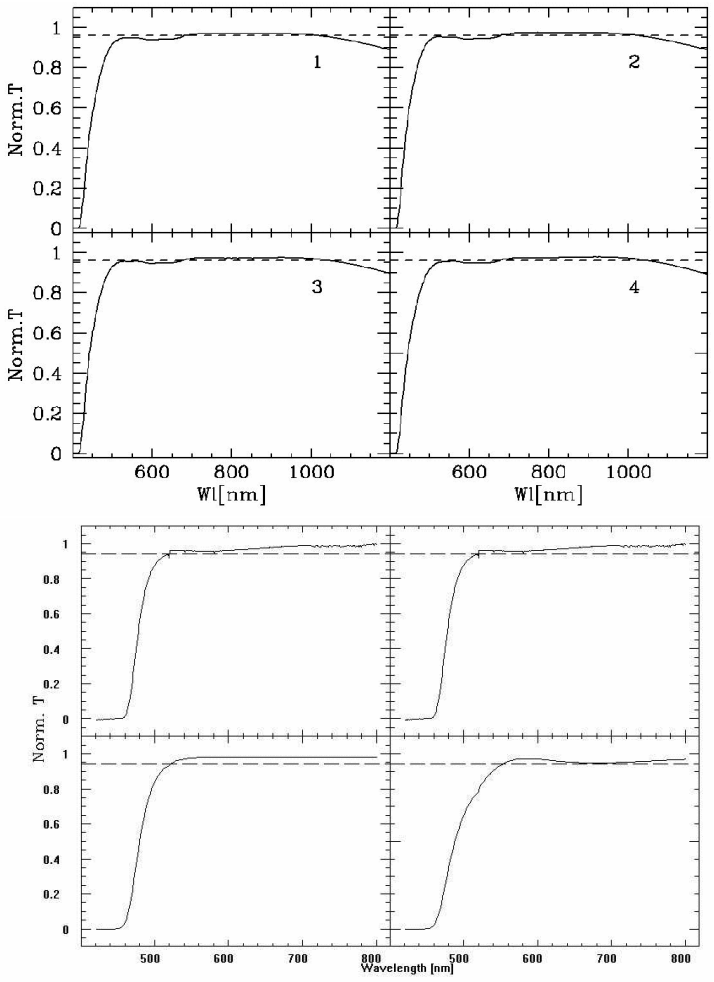


Figure A.4: GG435, GG475 transmission curves

Appendix B

VIMOS Grisms

This appendix contains the efficiency curves of all standard grisms available for VIMOS and the approximate wavelength range for a slit which is located in the field centre. Where it applies (e.g. wavelength range) the info presented in this Chapter relates to the old detectors.

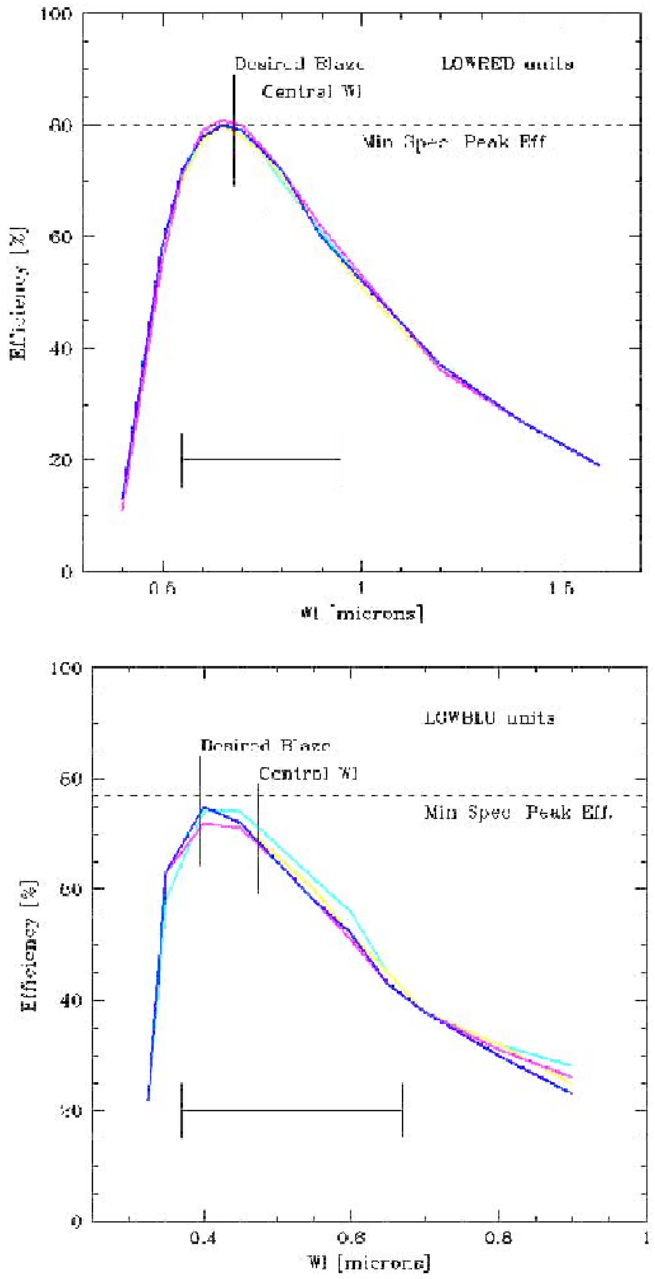


Figure B.1: Efficiency curve of the low resolution grisms LR_red, LR_blue. The vertical lines mark the desired blaze and the central wavelengths. The spectral range refers to the slit in the center of the field. The cutoff wavelength is in most cases given by the order separation filters, the red CCD limit or the limit of the VIMOS optics in the blue.

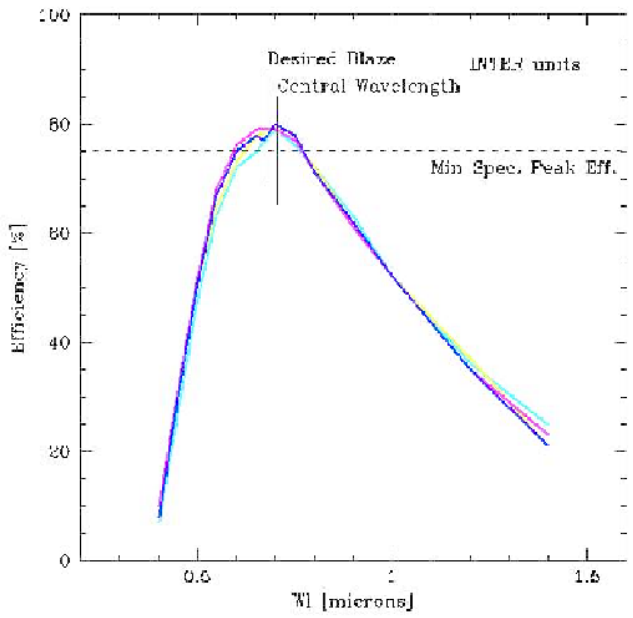


Figure B.2: Efficiency curve of the medium resolution grisms MR. The vertical lines mark the desired blaze and the central wavelengths. The spectral range refers to the slit in the center of the field. The cutoff wavelength is in most cases given by the order separation filters, the red CCD limit or the limit of the VIMOS optics in the blue.

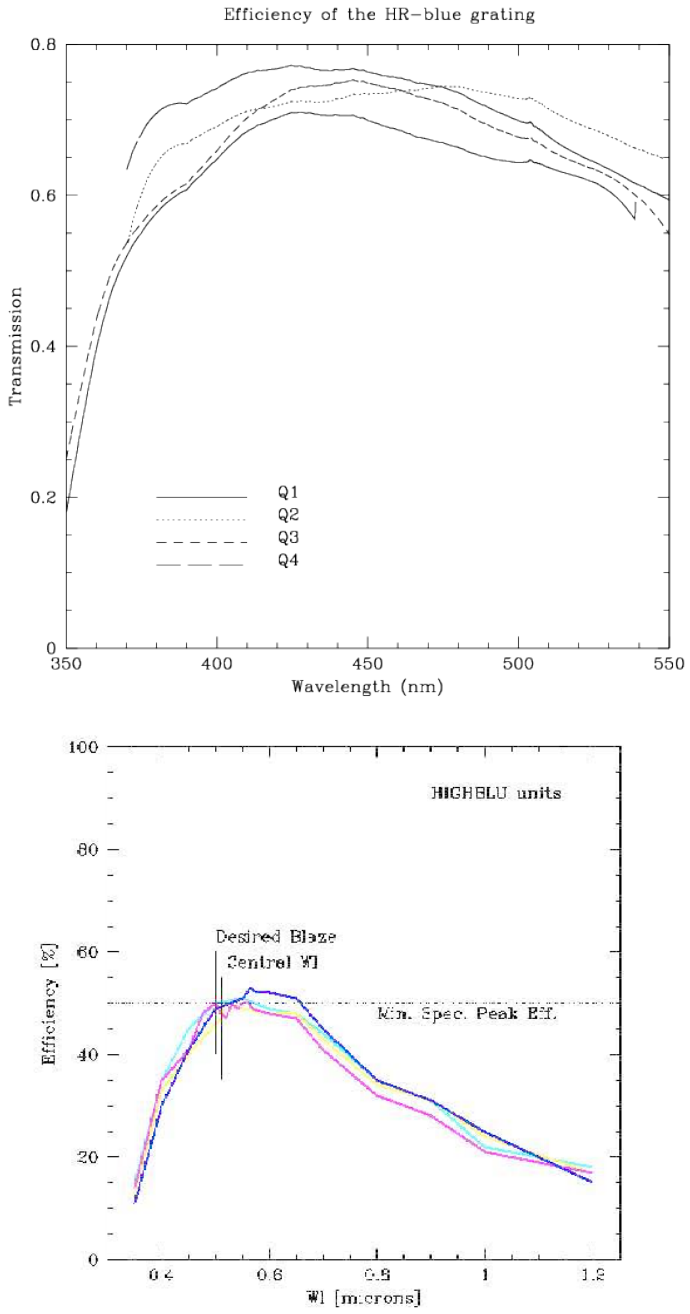


Figure B.3: Efficiency curve of the high resolution grisms HR_blue^{NEW}, HR_blue^{OLD}. The vertical lines mark the desired blaze and the central wavelengths. The spectral range refers to the slit in the center of the field.

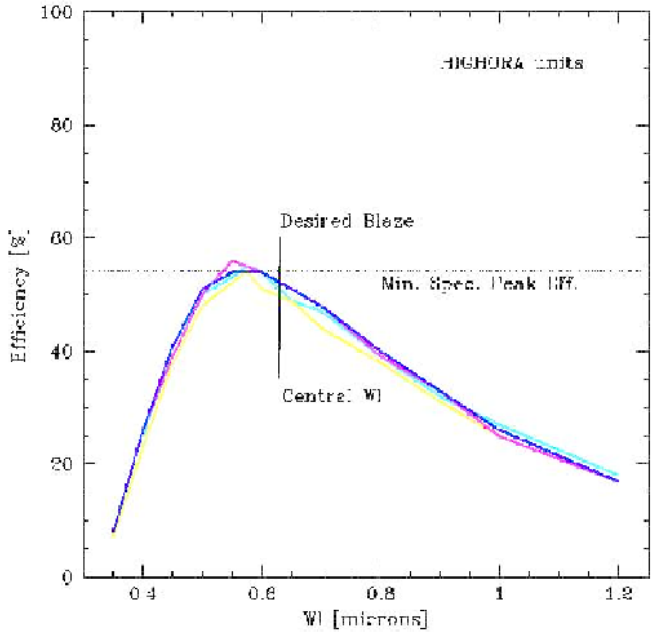


Figure B.4: Efficiency curve of the high resolution grism HR_orange. The vertical lines mark the desired blaze and the central wavelengths. The spectral range refers to the slit in the center of the field. The cutoff wavelength is in most cases given by the order separation filters, the red CCD limit or the limit of the VIMOS optics in the blue.

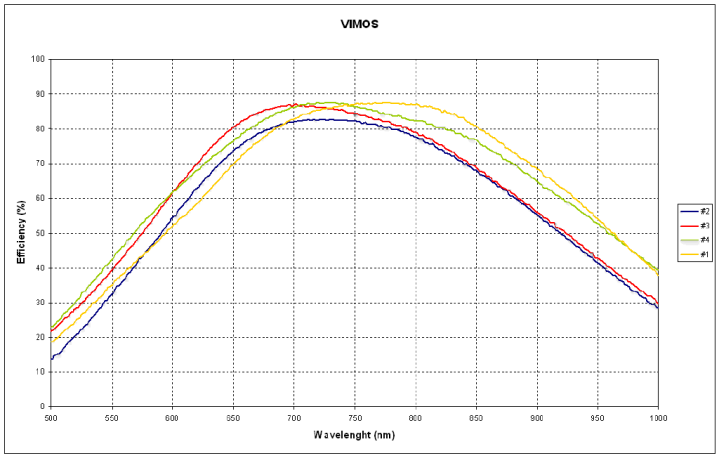


Figure B.5: Efficiency curve of the high resolution grisms HR_red VPHG. The spectral range and efficiency refers to the slit in the center of the field. The cutoff wavelength is in most cases given by the order separation filters, the red CCD limit or the limit of the VIMOS optics in the blue.

Appendix C

Old detector system: until May 2010

The old detector mosaic of VIMOS consists of four 2k×4k EEV 44-82 CCDs, thinned and back side illuminated, single layer coating. It will be in use until May 2010 (if the VIMOS detector upgrade goes according to plan).

Table C.1 indicates the basic characteristics of the VIMOS CCDs. Figure 2.9 shows the quantum efficiency curve of one of the CCDs.

Table C.1: Basic characteristics of the (old) VIMOS CCDs

Parameter	Value
Number of pixels	2048×4096
Pixel size (μm)	15
Dark current at –120° C (e^-/px/h)	<7
Deviation from Linearity (Full well; %)	< 0.5
Charge transfer efficiency	>0.999999

C.1 Detector read-out modes

The CCDs have two read-out ports but only one is used. This increases the read-out time but, as a benefit, the gain, offset, and read-out noise are constant along the entire CCD.

In spectroscopic mode, the full CCDs (2048×4096 pixels^2 are read-out; in imaging mode, readout is windowed to 2048×2400 pixels^2. In fact, in both spectroscopic mode and in imaging mode, the CCDs are vignetted by some hardware. In spectroscopic mode, the illuminated area is about 1970×4096 pixels^2, and in imaging mode the illuminated area is about 1970×2300 pixels^2. The actual values depend on the individual CCDs.

The default readout modes are indicated in Table C.2.

Table C.2: Old Detector System Readout Modes and Characteristics[1]

VIMOS Mode	Size	Speed	Binning	Gain	Port	Windowing	Readout time
Imaging	4×2k×2k	225kpx s^{-1}	1×1	Low	1-port	Not supported	1 m
Spectroscopy	4×2k×4k	225kpx s^{-1}	1×1	High	1-port	Not supported	1 m

[1]The new detector system should have these same modes.

C.2 Controllers

The 4 CCDs are controlled by two FIERA controllers. The detectors of channel 2 and 3 are controlled by FIERA A (VIMOSA), the detectors of channel 1 and 4 by FIERA B (VIMOSB).

C.3 Read-out noise and conversion factor

Table C.3 indicates the readout noise and gain values for the 4 chips. Note that these values are subject to change and are indicated here only for reference. Exact values to be found in the image headers under the following keywords: HIERARCH ESO DET OUT1 GAIN, and HIERARCH ESO DET OUT1 RON (the number x in OUTx could change depending on the output amplifier used).

Table C.3: Detector read-out noise and conversion factors. For reference only, subject to change

Chip	Read-out Mode	RON [e^- rms]	K [e^-/adu]
CCD 1	225 kpx s^{-1}, low gain (IMG mode)	5.3	1.70
CCD 2	225 kpx s^{-1}, low gain	5.2	1.86
CCD 3	225 kpx s^{-1}, low gain	5.3	1.95
CCD 4	225 kpx s^{-1}, low gain	4.9	1.80
CCD 1	225 kpx s^{-1}, high gain (MOS and IFU modes)	4.3	0.51
CCD 2	225 kpx s^{-1}, high gain	4.6	0.56
CCD 3	225 kpx s^{-1}, high gain	4.7	0.57
CCD 4	225 kpx s^{-1}, high gain	4.3	0.52

RON and conversion factor monitoring is available through the QC1 WEB pages

C.4 Fringing

These old detectors suffer from strong fringing in the red. With the z_Gunn and Bessel I filters the fringing amplitude is around 7% in imaging and in spectroscopy the amplitude of fringing for the HR grisms reaches in 900nm 40% for slits of 1".

This strong fringing was responsible for most of the flat fielding and sky subtraction woes in the red with these old detectors.

Appendix D

Abbreviations and Acronyms

The following abbreviations and acronyms are used in this manual:

ACQ	Acquisition
ADP	Aperture Definition in Pixels
ADU	Analogue-to-Digital Unit
AFC	Active Flexure Compensation
A/R	Adapter/Rotator
AT	Acquisition Template
BOB	Broker of Observation Blocks
CCD	Charge Coupled Device
DEC	Declination
ESO	European Southern Observatory
ETC	Exposure Time Calculator
FEU	Filter Exchange Unit
FIERA	Fast Imager Electronic Readout Assembly
FOMPU	Folding Mirror Positioning Unit
FPAL	Focal Plane Adaptation Lens
FWHM	Full Width Half Maximum
GEU	Grism Exchange Unit
GUI	Grafical User Interface
HR	High Resolution
IFU	Integral Field Unit
IOT	Instrument Operation Team
IMG	Imaging Mode
MEU	Mask Exchange Unit
MOS	Multi Object Spectroscopy Mode
OB	Observation Block
OS	Order Sorting
PRL	Pupil Relay Lens
PSF	Point Spread Function
PTV	Peak-To-Valley
P2PP	Phase 2 Proposal Preparation
RA	Right Ascension
RMS	Root Mean Square
RON	Read Out Noise
TIO	Telescope Instrument Operator
TSF	Template Signature File
VIMOS	Visible Multi-Object Spectrograph
VMMPS	Vimos Mask-Manifacturing Preparation Software

VLT	Very Large Telescope
Å	Ångstrom
e^-	Electron
cm	Centimeter
h	Hour
kpx	KiloPixel
min	Minute
mm	Millimeter
nm	Nanometer
px	Pixel
s	Second
μm	Micrometer

Index

active flexure compensation, 22
Aperture definition in pixels
    ADP files, 25, 30, 31

calibration units, 21
CCD, 5
    charge transfer efficiency, 20
    controller, 20
    dark current, 20
    exposure shutter, 21
    format, 19, 20
    full well, 20
    gain, 19, 20
    number of pixels, 20
    pixel size, 20
    QE curve, 19
    readout modes, 20
    RON, 19, 20

exposure shutter, 21

field of view, 5
filters, 5–8, 11, 21, 25, 123–127
    allowed combinations with grisms, 12
    broad band filters, 8, 123
    focus, 26
    no filter with LR grisms, 13
    order separation, 12
    order sorting, 12, 14, 130, 131, 133
    pre-imaging, 28
    resolutions with grisms, 17
    standard grism/filter combinations, 12
    user supplied, 12
fringing, 21

grisms, 4–7, 12, 14, 25, 33, 129
    allowed filter combinations, 12
    allowed filter combinations per OB (MOS), 32
    atlas of lines, 21
    atmospheric dispersion, 26, 27
    attached calibrations, 32
    blocking mechanism, 23
    calibration plan (IFU), 34
    exchange unit (GEU), 7
    fringing, 21
    HR-orange, 13
    HR-red, 13
    low resolution, 13
    LR, 12
    LR_blue, 26
    MR, 12
    MR+OS-blue, 12
    multiplex, 12
    multiplex (IFU), 17
    resolution, 13
    spectral coverage (IFU), 18
    spectral coverage and position in FoV, 14
    spectral coverage in different quadrants (IFU), 18
    spectral range, 12, 13
    spectral range (IFU), 17
    spectral resolution, 12
    spectral resolution (IFU), 17
    spectrum rotation, 23
    standard grism/filter combinations, 12
    VPH, 6
    VPH HR-red, 13
    VPH HR_red, 18

IFU masks, 14
    fiber arrangement, 14
image scale, 5
    IFU, 5
    IMG, 5
    MOS, 5
imaging, 7
    broad band filters, 8, 123
    filters, 123
    zero points, 8
IMG mode, 7
isophotal magnitudes, 8, 11

manuals, 1
masks, 7, 30, 31
    acquisition, 43
    ADP files, 44
    exchange at night, 32
    exchange unit (MEU), 6
    for spectrophotometric standard observation, 13
    manufacture in visitor mode, 32

mask-to-ccd matrix, 29, 32
number simultaneous, 6
pre-images for preparation of, 7
preparation software (VMMPS), 25
spectrophotometric, 46

observing, 25
observing modes, 5
direct imaging, 5
integral field spectroscopy, 5
multi-slit spectroscopy, 5
overheads, 32, 33, 35

P2PP
WEB page, 1
p2pp, 25
Paranal Science Operations
contact information, 1
WEB page, 1
Phase I, 35
PILMOS, 115
Application (Guidecam), 117
contributed catalogue, 118
GuideProbe Settings, 117
requirements, 115
restrictions, 115
source chart, 119
Proposal preparation
Phase I, 28, 35
Phase II, 28

red leak, 21

service mode observations
contact information, 1
observing with VIMOS, 25
shortcomings, 22
grism blocking, 23
grism induced defocusing, 22
IFU fringing, 22
IFU masks vignetting, 22
rotator angle induced defocusing, 23
spectrum rotation, 23
temperature dependent bias level, 24
temperature dependent image scale, 24
spectroscopy
grisms response, 129
standard instrument characteristics
VIMOS, 6

VIMOS
instrument components, 6
WEBpage, 1
VIMOS Upgrade Project
new CCD, 6
old CCD, 5
visiting astronomers
general informations, 1
observing with VIMOS, 25
WEB page, 1

zero points, 8